# The Secondary School Science Olympiad Experience: Coaches Opinions and Attitudes Regarding Participation and Content Acquisition 

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The Secondary School Science Olympiad Experience: Coaches Opinions and Attitudes Regarding Participation and Content Acquisition

A dissertation submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Curriculum and Instruction

## by

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#### Abstract

Science Olympiad (SO) is a team-oriented STEM competition that offers students the opportunity to participate in a wide range of STEM topics attracting students with varying STEM interests. This hermeneutic phenomenological cross-case study explored the experiences of 12 SO coaches with experience coaching middle school and/or high school teams. Educational settings for the teams included public schools, private schools, and homeschool. Coaches were asked to fill out an open-ended questionnaire about their SO coaching experiences. Based upon questionnaire responses, coaches were invited to participate in follow-up interviews.

The experiences related by the coaches in the interviews were written as case studies and a cross-case analysis was conducted to reveal patterns and themes across the coaches' experiences. Themes explored encompassed coaches' views on student benefits as well as personal benefits to the coaches; challenges coaches perceived students overcoming as well as challenges experiences for the coaches; and the amount and type of support coaches have discovered they and their students need in order to have a positive SO experience.

Coaches indicated that they found coaching an SO team to be enjoyable or rewarding because they saw students having fun while learning. Some coaches also stated that SO allowed students to gain knowledge (literacy) not available to them in the classroom setting and they viewed this knowledge to be especially valuable for the student pursuing a STEM career in the future. Key findings of coaches' perspectives included that student participation in SO confirmed STEM career choice, assisted in STEM skills acquisition, and encouraged several areas of personal development. Some coaches reported their own personal knowledge and skill growth as benefits to coaching. Some key findings support other related research. The perspective that competition offers opportunities for personal growth coincides with studies


conducted by Wirt (2011) and Schmidt (2014). Examples given by coaches of STEM knowledge acquisition as a part of preparation for competition match with some literacy goals stated in the NGSS (NRC, 2013) document and the general literacy idea promoted by UNESCO (2017) that literacy exists along a continuum where individuals find the level of competency needed for their personal interests and career goals. Coaches' examples of students enjoying and benefiting from competition support the findings of studies by Campbell and Walberg (2011), Wirt (2011), Ozturk \& Debelak (2008), Abernathy and Vineyard (2001), and Verhoeff (1997). Many coaches discussed the importance of mentors for student success in SO competition. The descriptions of the guidance given by the mentors' support statements by Ozturk and Debelak (2008) claiming that an adult guide is necessary for students to glean the maximum benefits from participation in competitions.

Most of the coaches in this study were eager to share their experiences and offer advice to anyone interested in coaching an SO team. Included in the findings of this study are recommended strategies for acquiring funding, recruitment of team members, team structuring, team building, and promoting team recognition and publicity for achievements.
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## Dedications

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## Chapter 1: Introduction

## Statement of the Problem

Competitions of various sorts have long been a part of the educational landscape and, as such, are a valuable component of instruction that can increase excitement and interest among students in schoolwork (Reck, 1951; Toppo, 2016). The Science Olympiad (SO) is one of several science related competitions bearing the name Olympiad such as the Math, Physics and Chemistry Olympiads alongside other competitions such as the familiar "Science Fairs" and especially the International Science and Engineering Fair (ISEF). All of these encourage indepth investigation into a particular discipline. These competitions are further related in that they are student-centered competitions. However, they differ in the types of experiences they offer participants. Formed in the U.S. in the 1980's (SO, Inc. website), the Science Olympiad is unlike other competitions that bear the name Olympiad in that it combines the individual exam with a hands-on type of experience or building project. Science Olympiad participants become part of a fifteen-member team that competes in a combination of 23 categories. Each of these categories offers experiences that encourage the application of broad science and technology knowledge in multiple areas instead of one specific area such as chemistry or math. These experiences can range from demonstrating knowledge on paper and pencil exams to activitybased elements such as laboratory investigations or building items. This may occur on-site or prior to the competition. Participants on the team typically enter multiple categories for competition. The main goal of the Science Olympiad is to improve the quality of science education while increasing student interest in science along with providing recognition of both students and teachers who make outstanding achievements in science education (SO, Inc. website).

Despite more than forty years of Science Olympiad participation by tens of thousands of students, there is still much we do not know about the impact these experiences make and how and why they appeal to students and coaches to draw them into the competitions annually.

## Purpose of the Study

This study explores the nature of opinions and attitudes coaches express regarding the science knowledge, skills, and personal growth opportunities afforded by participation in SO to both them and their students. Through the exploration some insight is shed into what coaches find appealing about SO participation and why they chose to coach it. Though Science Olympiad offers competitive opportunities for teams in elementary (Division A), middle school (Division B), and high school (Division C), this study will focus on middle and high school team coaches.

## Conceptual Framework

This study was guided by the hermeneutic phenomenology framework. However, due to the researcher's desire to explore the perspectives of as many individuals as possible in the geographic region of interest prior to developing interview questions, a qualitative questionnaire was employed. Since questionnaires are not generally recommended for phenomenological studies because they are viewed as limiting descriptive responses (Galasinski \& Kozlowska, 2010; van Manen, 2016) either by structure or by space allowed for the response, the Phase I questionnaire (Appendix A) was designed following the methods of naturalistic inquiry. The naturalistic paradigm as presented by Lincoln and Guba (1985) as a type of post positivist paradigm. The design of a naturalistic inquiry is by necessity an emergent one (Erlandson, Harris, Skipper, and Allen, 1993) and can include both qualitative and quantitative methods (Erlandson, et al, 1993; Lincoln \& Guba, 1985). Its purpose here was to reveal themes in the
questionnaires that were subsequently used to frame the questions for the semi-structured interviews (Appendix B) used for Phase II.

Phase II used the framework of hermeneutic phenomenology. Phenomenology is the study of experience as it is lived (Friesen, Henriksson, and Saevi, 2012; van Manen, 2016). Hermeneutics is the art and science of interpretation (Friesen et al., 2012). Van Manen states, "Hermeneutics phenomenology is a human science which studies persons." (p. 6) Phenomenology alone provides a description of a lived phenomenon whereas hermeneutic phenomenology seeks to explore the ways in which a person can experience a phenomenon. Friesen et al. (2012) in discussing hermeneutic phenomenology state "... it is impossible to study experience without simultaneously inquiring into its meaning, and it is impossible to study meaning without experiential grounding." (p. 3)

This study explores the ways in which twelve Science Olympiad coaches experience leading students in the competition. The researcher seeks to interpret the meanings these experiences have for these coaches with the goal of gaining insight into their motivations to choose to coach and continue coaching. This fits with the statement by Friesen et al (2012) "Hermeneutic phenomenology is consequently the study of experience together with its meaning." (p. 1) Friesen et al. also credit van Manen with developing a type of phenomenology that is "explicitly and emphatically hermeneutic and also having a focus which is primarily educational." (p.3) They promote van Manen's hermeneutic phenomenology as being especially well suited for educational research. For investigating lived experiences, van Manen recommends the interview as a preferred method over surveys or other instruments where individuals are asked to write about their experiences. He says, "Most people find writing
difficult. They will talk with much more ease and eloquence and with much less reserve than they will write their thoughts on paper." (p. 64).

## Introduction to Science Olympiad

An introduction to Science Olympiad might best be accomplished in the form of a comparison to the International Science and Engineering Fair (ISEF) since, like the author, many readers may be slightly more familiar with ISEF. The two competitions are different in several ways. ISEF is mostly designed for participants to perform individual research and experimental projects which are presented to expert judges in that field first at a local fair. Projects carried out by teams of two are allowed, but are not as common as individual projects and, in the researcher's personal experience, team projects are typically discouraged. Winning projects advance from local fairs to regional fairs and then potentially to state fairs. Ultimately, participants with top projects at regional and/or state fairs are selected to compete at the international fair. Students focus on one project in a specific field all year and sometimes for several years if they take the findings of one project and design another to further investigate those findings.

ISEF participants compete in one of 21 different (see Appendix C) STEM disciplines in both middle and high school divisions (Society for Science website). A major difference in the approach between the two competitions is that ISEF focuses on an in-depth project into one main discipline by one individual. Science Olympiad offers students opportunities to compete with partners in groups of two or three in several of 23 different STEM related events. Table 1.1 gives the events and categories for the 2023 SO competition year. The list of event descriptions for middle school (Division B) is given in Appendix D and high school (Division C) is in Appendix E. These student groups compete for prizes in their individual events as well as earn
points for their overall team comprised of up to 15 members. These 15 students attempt to divide up in such a way that the team has members competing in all of the 23 events to maximize their point potential. Teams may participate in invitational meets sponsored by other teams as a means to practice for regional or state meets. The terms meet and tournament are used interchangeably by SO coaches. If a state has a large number of schools participating, there may be several regional meets to determine which teams will compete at the state meet. The winner of the state meet will advance to the national competition.

Table 1.1. 2023 Science Olympiad National Tournament Events and Categories

|  | Life, Personal, and Social Science | Earth and Space Science | Physical Science and Chemistry | $\begin{array}{\|c} \hline \text { Technology } \\ \text { and } \\ \text { Engineering } \\ \hline \end{array}$ | Inquiry and Nature of Science |
| :---: | :---: | :---: | :---: | :---: | :---: |
| BDivision (Middle School) | - Anatomy \& Physiology <br> -Bio-Process <br> Lab <br> -Disease <br> Detectives <br> -Forestry <br> -Green <br> Generation | -Dynamic Planet <br> -Solar System <br> - Meteorology <br>  <br> Minerals <br> -Road Scholar | -Can’t Judge a Powder <br> -Crave the Wave <br> -Crime Busters <br> - Sounds of Music <br> -Storm the Castle | -Bridge <br> -Flight <br> -Roller <br> Coaster <br> -Wheeled <br> Vehicle | -Codebusters <br> -Fast Facts <br> -Write it Do It |
| CDivision (High School) | - Anatomy \& Physiology <br> -Cell Biology <br> - Disease <br> Detectives <br> -Forestry <br> -Green <br> Generation | - Astronomy <br> -Dynamic Planet <br> -Remote Sensing -Rocks \& Minerals | -Chem Lab <br> -Environmental Chemistry <br> -Forensics <br> -It's About Time <br> -Trajectory <br> -WiFi Lab | -Bridge <br> -Detector <br> Building <br> -Flight <br> -Scrambler | - Codebusters <br> -Experimental Design -Fermi Questions <br> -Write it Do It |

The SO participants have less freedom to choose their research within a field than the ISEF participants. Each Science Olympiad event takes a specific area within a field and guides
students to focus on gaining that knowledge. Most SO events have both a written test over knowledge of the topic and a hands-on portion for students to demonstrate skills. Events classified as building events (builds, for short) require students to build an apparatus to perform a specific task. The materials used and size of the apparatus are specified in the rules. Any apparatus not meeting the specifications is disqualified. Most building events typically do not have an accompanying written test, but students may be required to exhibit a logbook of previous tests performed with the apparatus showing performance results or data collected depending on the type of apparatus.

An ISEF participant will go in depth on one research topic in their chosen field and may learn techniques from closely related fields while conducting their research. A Science Olympiad student will go in depth into a specified topic in one field for each event entered. Though it is possible for a student to be allowed to enter only one event in SO, it is rare because the 15 -member team ideally should cover all 23 events. This means most team members need to enter three or four events. The ISEF student (excepting the rare team) is a solitary researcher assisted by the aid of a mentor teacher or, as in the case of many successful participants, the mentorship of a professional researcher at a research institution. The SO student may also benefit from professional mentorship depending on their school, but they are mentored alongside their partner and, in larger schools that run multiple teams, other student partners that are also competing in that event. Therefore, the mentoring sessions become small group sessions for two to six students or a few more if the category is the same in both middle and high school and the teams practice together. SO competition discourages students from entering events alone though it is allowed. The Science Olympiad experience promotes the idea of teamwork and participants supporting each other.

To summarize, it could be said that ISEF focuses on one person investigating any topic they choose in great depth while SO focuses on pairs investigating several of a list of specifically defined topics. It appears that ISEF encourages development of expertise in an area for a potential future career while SO encourages detailed knowledge for a sampling of different career possibilities. Both competitions have their benefits and limitations for the student, but it seems that each fills a different niche for students with different approaches to accessing extracurricular science education.

## Significance of the Study

This study adds to the literature by enhancing understanding of the various experiences of the coaches for the purpose of understanding why they choose to participate in SO. This study will also explore coaches' opinions about perceived gains in science knowledge, personal skills and other valuable experiences they believe students gain from Science Olympiad participation. A review of the literature revealed two studies that focused on SO coaches as opposed to students. Robinson (2003) asked coaches about the relationship between coaching and teaching. Swanson (2023) surveyed elementary school coaches to measure their motives for volunteering. While Swanson's study looks at coach motivation, it is elementary school Science Olympiad competition which is a different structure from the middle school and high school competitions. In the elementary (Division A) there are no official formats, event descriptions, nor competitions. The events offered for student participation can vary by school. Most Division A competitions are expected to be intra mural and the events can be designed by the teachers (Science Olympiad website). Swanson found that elementary teachers had several positive effects from their coaching experiences (Swanson, 2023). Specific benefits named were an enhancement of science and pedagogical knowledge as well as prompting them to use more hands-on science
activities in their classrooms. A study of experiences of middle school and high school coaches to reveal the personal rewards they perceive and to shed insight into sources of their motivation has not been done. Findings from this study will begin to fill that gap. Themes that emerge from the question about the science knowledge coaches see students gaining are compared to the various definitions of science literacy presented in the literature review, as well as a comparison to the stated goals of the Science Olympiad. This adds to the understanding of the place Science Olympiad fills in the coaches' perspectives for enhancing science literacy. Questionnaire items delving into the different types of support that coaches receive from various sources in their school and community were expanded in the Phase II interviews with the purpose of gaining insight into social views of academic competitions and further enhance the understanding of the experience for the coaches. This provides some understanding of the challenges that coaches must deal with as well as illustrates the role school and parental support plays in the life of a team.

## Research Questions

Research Question 1: According to coaches, what knowledge, skills, and personal growth opportunities does Science Olympiad provide?

Sub-Question 1A: What experiences in these regards do coaches think students are having?

Sub-Question 1B: What experiences in these regards do coaches relate as personally applicable about their work in Science Olympiad?

Research Question 2: What are the challenges/barriers to Science Olympiad participation?

## Overview of Method

Phase I utilized a questionnaire featuring open-ended items for the Science Olympiad coaches (Appendix A). The researcher visited three tournaments in person and asked the coaches to fill out the coaches' questionnaire. The findings of these questionnaires were analyzed and used to design Phase II and specifically to develop a set of interview questions (Appendix B).

For Phase II a list of coaches as potential interviewees was made and invitations to participate were extended. Twelve coaches responded to the interview invitations to schedule an interview with the researcher. Yin (2018) recommends using twelve or fewer. Further discussion of the sampling rationale is given in Chapter 3. Interviews were conducted online.

Lincoln and Guba (1985) recommend a Phase III for case studies. They term this the "member check" (p. 236). Each interviewee was sent a copy of their individual Case Study and asked to comment on anything that they did not feel was interpreted correctly or to clarify any misunderstandings in the report.

## Assumptions

Since participation was voluntary, the personal backgrounds and experiences of each of the coaches as well as the type of school each was affiliated with varied widely. It was discovered that several coaches were involved with both the middle and high school teams at their school. Therefore, it is assumed they will have more depth of experience to relate. It is further assumed that coaches responded to the questionnaire items and later interview questions honestly and interpreted the questions as intended to give relevant responses.

## Delimitations

Findings in Phase I were limited by the quality of responses given. Previous research shows that participants may provide opinions or explanations of why they feel a certain way instead of describing their opinions or attitudes about the experience in the question (Englander, 2016) Also, any study will only reveal some of the ways participants experience the phenomenon. There will always be other experiences not revealed in the study. Researcher bias is also difficult to determine or detect.

Figure 1.1. Delimitations


These factors illustrated in Figure 1.1 influenced the development of the interview questions in Phase II and could potentially have limited information that could have been found. Interview questions were open-ended. However, the researcher's inexperience in writing questions for both the questionnaires and the interviews may have resulted in questions that did not delve as deep as possible. Also, the researcher's inexperience in conducting interviews could also mean that opportunities to pursue lines of inquiry were missed. If questions or the following conversations did not trigger certain memories or stories for the interviewee, then those experiences could not be exposed in this study.

## Reflexivity Statement

Prior to this study I had not been involved with Science Olympiad. My experience with science competitions was solely with the International Science and Engineering Fair (ISEF). I began science fair competitions in junior high school as a requirement for an honors program without any expectations beyond fulfilling the requirements for the class contract. That first project earned $2^{\text {nd }}$ medalist at the regional fair and advanced to the state fair. I enjoyed the state fair experience so much that I set it as a goal to try to return every year. That goal led to many science education opportunities during my junior and senior years. These opportunities included a scholarship to attend a summer science program at Southwestern Oklahoma State University where I earned college credit, an internship at Brookhaven National Laboratory, and a trip to the international (ISEF) fair held that year in Puerto Rico. These experiences were life changing and made me aware of the impact science competitions could have on a student.

I continued to be involved in ISEF as an adult, returning first as a judge at my high school alma mater and then later at other neighboring schools as well as judging at the regional fair which I had previously won. When I became a secondary school teacher, I coached students with ISEF projects for three years before becoming a college instructor at the college which sponsored the regional fair. I then became an assistant director for the regional fair and then alternated between director and co-director for the next 15 years.

In 2020 the college administration ended the sponsorship of the regional fair. The fair had been struggling for a number of years and I had fought to keep it going for the last ten years. Over those years, I was faced with the constant challenge of keeping schools wanting to compete and trying to recruit new schools into the competition in order to keep the fair alive. It was a losing battle and I questioned why this was happening. I talked with ISEF coaches and the
reasons I heard were varied across a wide range of issues and those answers possibly warrant a study of their own. However, independent of these talks with ISEF coaches, I heard of another competition, Science Olympiad (SO) that seemed to be growing nationwide at a time when ISEF growth was looking stagnant. No schools in the service area of my regional fair had left ISEF to compete in SO. Currently, there are no schools in my former fair's service area with an SO team. So, it was not that SO was pulling schools away from my fair, but SO did seem to be gaining interest in schools elsewhere and some not previously involved in ISEF. I became curious about what was appealing to these schools. That curiosity led to this study. My attitude was not to find out what the "enemy" was doing and later use that knowledge to try to pull people away from SO and over to ISEF, but an interest in what is appealing to people about SO. I wondered if perhaps this is a science competition my college should consider hosting. With no schools in my service area having SO teams, I would be faced with the same recruiting issues I had with ISEF. Therefore, I wanted to learn what it was about SO that makes it appealing. Knowing that for ISEF, the coach is a major force behind the school program, I was specifically interested in learning what motivated people to volunteer to coach Science Olympiad.

Because of my ISEF experiences I entered into the study with the assumption that all of the coaches would think the SO experience is beneficial for their students and the coaches themselves derive one or more types of benefits from coaching. I also assumed that all the coaches would also be teachers at the team's school and that they would be either science or math teachers and could make comparisons and comments about the students' performances in class as related to their SO participation. I expected that all teams would be affiliated with a public or private school and that there would be one team per school. Due to this idea of only
one team per school, I expected that there would be an exclusivity about the teams and a try-out process would exist at the beginning of each year to select the "best fit" members for the team.

## Limits on Generalizability

According to Van Manen (2015), the purpose of a hermeneutic phenomenological study is not to produce generalizability. In fact, he states, "The only generalization allowed by phenomenology is this: Never generalize!" (p. 22). Lincoln and Guba (1985) say "... generalizations are assertions of enduring value that are context-free." (p.110). Since cases that comprise a phenomenological study are investigations of lived experience within a specific context, it is difficult to remove the experiences from their context. Yin $(2018,1999)$ states that cases are not to be regarded as samples and, therefore, even multiple case studies should not be regarded as similar to experiments with multiples samples.

Lincoln and Guba (1985) prefer to focus on the transferability of case study findings. The idea is that if two contexts are sufficiently congruent then lessons learned from experiences in one context may be applicable to the other. Therefore, this study seeks to gain insight into the lived experiences of Science Olympiad coaches. The insights gained may be useful to other coaches of SO or those contemplating being a Science Olympiad coach due to the similarity of context within the structure of the Science Olympiad competition and the potential that a coach of similar school situation may be found within one of the cases presented here. Insights may not be applicable to coaches of other science competitions if the structure of those competitions is quite different from SO and if their school situation is dissimilar to any of the coaches in this study.

## Chapter Two - Literature Review

This chapter contains a review of the literature pertinent to the research questions. Since most competitions as far back as the colonial-era spelling bees make some type of claim toward improving literacy, this review starts with a discussion of the history and structure of the Science Olympiad. The review then delves into how literacy has been defined and, in particular, what is meant by the term science literacy. The third part of the review looks at the history of academic competitions in the U.S. beginning with spelling bees, progressing through the development of specific science focused competitions. The chapter concludes with a discussion of how this research is situated in the current literature.

## History and Introduction of the Science Olympiad Competition

The Science Olympiad, began in Michigan in the early 1980's due largely to the efforts of Dr. Gerard J. Putz and John C. Cairns (Science Olympiad website). It is a national competition with age divisions encompassing K-12. However, only the Middle School and High School divisions attend the national championships. This competition is different from other competitions bearing the name Olympiad in that there are a variety of activities involved across many STEM fields. These individual activities are called events and 23 events are offered for students to compete in each year. For a table of all 23 middle school (Division B) events offered each year since 2008, see Appendix D. The 23 high school (Division C) events offered each year since 2008 are shown in Appendix E. The tables show how some events are standards that are offered each year while other events are on a rotating schedule. Sometimes there are a few "trial" events that are being tested out for future inclusion and teams can opt to compete in those. This accounts for some years having more than 23 events listed on the tables. There are two basic structures for events. Some events consist of an exam often paired with a field related
hands-on portion. Participants gain points for their exam answers and performance of the handson portion. Other events (referred to as builds) require participants to build items prior to the competition and test the item's performance at the tournament or require the students to utilize materials given to them at the competition to build an item to a certain standard or to perform a specific task within a specified time period. All portions of an event are scored by the individual event judges.

In 1988, Michigan State University held the first Science Olympiad National Tournament (Schmidt, 2014). All 50 states are currently represented at the national level by approximately 7,000 secondary schools annually (Science Olympiad website). The goals of the non-profit organization are to improve the quality of science education while increasing student interest in science and to provide recognition of both students and teachers who make outstanding achievements in science education (Science Olympiad website). The specific goals are divided into two types and are as follows:

- To create a passion for learning science by supporting elementary and secondary Science Olympiad tournaments at building, district, county, state and national levels with an emphasis on teamwork and a commitment to excellence.
- To improve the quality of K-12 science education throughout the nation by changing the way science is perceived and the way it is taught (with an emphasis on problem solving and hands-on, mindson constructivist learning practices). This goal is accomplished
through in-depth core curriculum training workshops and the distribution of curriculum materials.
- To celebrate and recognize the outstanding achievement of both students and teachers in the areas of science and technology by awarding thousands of certificates, medals, trophies, and scholarships.
- To promote partnerships among community, businesses, industry, government and education.
- To bring science to life, to show how science works, to emphasize problem solving aspects of science and the understanding of science concepts.
- To develop teamwork and cooperative learning strategies among students.
- To make science education more exciting so more students will enroll in science courses and engage in other science activities like science reading, fairs, meetings and field trips.
- To promote high levels of achievement and a commitment to excellence, to demonstrate that American students can perform at levels that surpasses expectations of even practicing scientists and engineers.
- To attract more students particularly females and minorities to professional and technical careers in science, technology, and science teaching.


## (Science Olympiad website)

Participants in the Science Olympiad engage in events in pairs or groups of three in a few events. These small groups are part of a larger team of 15 students representing their school. The 23 categories are distributed across the three broad areas of the Next Generation Science Standards (NGSS) science standards (Science Olympiad website). There are events offered in the science concept and knowledge area, in the science processes and inquiry skills area, and in the science application and technology area (Science Olympiad website). Invitational tournaments (sometimes referred to as meets) are hosted by schools as practice competitions. Teams outside of the host school are invited to attend and this can be a valuable fund-raising opportunity for the host school. As well as competing for placing within each category, students earn points for their school team in the categories they compete for an overall school team standing. Some states with a large number of teams require teams to compete in a regional tournament in order to qualify for the state tournament. In other states all teams are eligible for the state competition. The winner of the state tournament will advance to the national competition (Science Olympiad website).

## Science Olympiad Participation and Science Literacy

Science teachers want to find ways to allow students to experience the excitement and joy created when one engages in the doing of science. They are often seeking activities that give meaning and application to the theory and facts which make up most of the classroom experience. Hands-on laboratory activities can be curtailed in the classroom by the time
constraints of the class period and budget limitations on purchases of supplies. The time constraints push the issue to find an afterschool extra-curricular activity that can offer these experiences. In addition to making science fun and exciting, the teacher has a desire to enhance science literacy for the student. Therefore, the extracurricular activity must fulfill these several objectives.

The student with a particular passion or driving curiosity can find relevant categories within those offered by the Science Olympiad events such as Forensics, Flight and Chem Lab to name just a few. Short descriptions for Division B events can be found in Appendix D and Division C event descriptions are given in Appendix E. Enabling students to find and explore areas in which they are particularly talented and/or interested is paramount to furthering their interests in and possible career in the sciences. In furthering the student's education, Science Olympiad participation allows opportunities for reinforcing one or more of the performance expectations given in the NGSS. It also allows for talent development beyond functional literacy by allowing students to apply content and go beyond the school curriculum. As previously noted, the wide variety of events offered by the Science Olympiad allow the student to explore specialized areas of science, which is something not often possible in a classroom environment. The case made in this discussion of science literacy is that there is no one definition. UNESCO has found that there is no one literacy for all and, likewise, no one science literacy for all. The approach of a science literacy for all created an educational experience that made science tedious and unappealing to many and yet does not serve those who remain interested. Participation in the Science Olympiad can provide students a choice of paths to their desired literacy in a competitive and enjoyable environment.

## Science Literacy

Defining science literacy is an elusive endeavor. The definition needs to fit the purpose. When one reads the literature, one finds a variety of imprecise definitions for science literacy (DeBoer, 2000) and incongruous lists of attributes one must possess to be scientifically literate (Lederman et al, 2013). To simplify, Hazen \& Trefil (1991) take the citizenship view that science literacy is the science you need to know to understand public issues. McComas (2014) gives a broader statement that it is: "the knowledge and understanding of scientific concepts and processes in order to make personal decisions, participate in civic and cultural affairs, and enter science and technology careers" (p. 92). This definition is a distillation of the aspects of science literacy described in both the National Science Education Standards (NSES) (National Research Council, 1996) and A Framework for K-12 Science Education (Framework) (National Researcher Council, 2012). These two sources as well as other definitions of science literacy can take several paragraphs or pages to describe. The problem arises when these definitions are employed as the purpose statement and goal of science education. To know that we have achieved the goal we must have an outcome or set of outcomes that are tangible (measurable). For an achievable definition of science literacy, we must answer the questions:

1) What knowledge?
2) What depth/level of understanding?
3) Which concepts?
4) Which processes?

If we look to general literacy as a model for determining the definition and purpose of science literacy, we find a similar discord in definitions. However, looking to legal precedence to give a court supported definition of what minimum literacy is, we can state that it is that level
which allows a person autonomy in self-education and enrichment and prevents one from experiencing social inequality (Shah, 2016). Interpretation of this could be situation and location dependent. This is a view of literacy utilized by UNESCO (2011). A person surrounded by highly educated people would need a higher level of reading literacy to avoid experiencing social inequality. That said, can a basic, universal definition of a basic science literacy be found? This section will explore that question and the personal and societal implications of what a basic science literacy means. Finally, I will examine the contributions Science Olympiad participation can make to an individual's level of science literacy.

## Defining science literacy.

To some extent science literacy depends upon general literacy and for this purpose, we use the traditional idea of literacy as being the ability to read, write, and use numbers. More recently, the definition has expanded to mean a competence in any area not necessarily text based. Of course, science is steeped in textual symbols and numbers, therefore a person must be able to at least read basic sentences before one can read a scientific explanation or definition.

A current definition widely referred to as well as used in many places around the world for general literacy is found in the recent document, Reading the past, writing the future: Fifty years of promoting literacy. Here UNESCO (2017) defines literacy as:

Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with various contexts. Literacy involves a continuum of learning in enabling individuals to achieve his or her goals, develop his or her knowledge and potential, and participate fully in community and wider society.

The UNESCO report looks back at the history of literacy as it has developed over the past fifty years and identified "four broad conceptions of literacy that characterized successive periods of the last fifty years" (p.38) and which led to the development of the current definition. These conceptions are:

1) Literacy as a stand-alone skill
2) Functional literacy
3) Literacy as empowerment
4) Literacy as social practice

These four categories provide a continuum along which literacy can progress and parallel the multiple literacies presented in the Next Generation Science Standards (NGSS). The following section will explore how these multiple literacies developed.

## The history of teaching science literacy.

A concern about students' understanding of and education in the natural sciences is nothing new, having existed since the agricultural depression of 1892-93 (Comstock, 1986). Comstock's Handbook of Nature Study was one answer to that concern (Kohlstedt, 2005) followed by Dewey who criticized the previous efforts (Dewey, 1910). The Progressive era philosophies focused mostly on enriching the individual and teaching science for good citizenship. They influenced education up through the war years but began to decline in the post war era. World War I brought a shift in science education philosophy from a focus on individual enrichment and community benefit to a focus on what knowledge is beneficial or detrimental to the nation. World War II brought a new urgency to science education and resulted in another shift in emphasis. The increased need for technically trained individuals and the role science
played in ending the war focused efforts to train more people for science and technical careers (DeBoer, 2000; Wissehr, et al, 2011). The emphasis after WWII shifted from science for citizenship to science for professionalism. New programs for change rapidly pushed previous programs aside. Teaching for content took the forefront in large part because content could be more easily and quickly assessed than students' understanding of science processes and application. (Mershon \& Schlossman, 2008).

The successful Soviet launch of Sputnik I in October 1957, followed quickly by Sputnik II a month later shocked the American public (Wenning, 2006; Wissehr et al, 2011). The presence of the Soviet satellite carried with it the implication that the US was now militarily vulnerable (Wissehr et al, 2011). The subsequent failure of the Naval Research Laboratory to launch its Vanguard rocket in December (Harris \& Miller, 2005) prompted President Eisenhower to issue a message to the committee on Education and Labor in January 1958 regarding the need for increased training of scientists. He stated, "Our immediate national security aims - to strengthen our Armed Forces and improve the weapons at their command - can be furthered only by the efforts of individuals whose training is already far-advanced" (Eisenhower, 1958, pp. $1 \&$ 2). To produce these individuals, he continued, ". . . we must necessarily give special. . . attention to education in science and engineering" (Eisenhower, 1958, p. 2)

Concerns for national security continued to fuel support for science education and on September 2, 1958, President Eisenhower signed the National Defense Education Act (NDEA) (Harris \& Miller, 2005). This legislation aimed to increase qualified workers for science and technology fields (Rudolph, 2014). This provided an official turning point away from the progressive ideas and toward a more rigorous curriculum focused on fundamental ideas of each discipline (DeBoer, 1991).

The emphasis toward content knowledge for ease of testing did not sit well with some educators who still followed Dewey's ideas about "so much ready-made knowledge" and believed that processes were an important aspect of science literacy. The controversy that dominated throughout the 1980's centered around the issue of science education for science content versus science education for understanding of science-based social issues (DeBoer, 2000).

The Next Generation Science Standards (NGSS) resulted from the efforts of several organizations working together to produce standards that would provide depth and quality instead of breadth and quantity. It built on and replaced several programs that came before it. The NGSS outlines three essential dimensions for developing science literacy. The three dimensions which include disciplinary core ideas, science and engineering practices, and crosscutting concepts, serve to unite aspects of science education previously separated. It would seem the century old debate over whether science literacy should focus on content, processes of science, or relevance to the world can cease as each standard is explored through all three dimensions.

However, look for a definition of science literacy in the NGSS and you will not find a concise summary or several paragraphs to pages outlining the attributes of a scientifically literate person that one finds in the publications that preceded it. The definition of science literacy NGSS proposes is given in the entirety of the document. The NGSS contains and describes multiple science literacies through which a person can progress or from which one can choose. The document aligns with the UNESCO idea of literacy as a continuum along which people move to the point of their need. The definition is broken into levels and disciplines. Using this, one could determine to what level of science literacy one aspired or needed. This is science
literacy as social practice. Not requiring everyone to train to be a scientist but allowing everyone the opportunity to gain the science literacy needed for careers and individual quality of life. However, this does not appear to align with current practices in science classroom education.

While the NGSS focusses more on the processes and less on the content, that is not the way assessment is done. As previously stated, content knowledge is easily measured while processes are difficult to assess. State tests and college entrance exams are all standardized tests that by nature must rely heavily on multiple choice content laden questioning. This predicament forces teachers to teach content for the tests while trying to work in the processes as best as they can. School funding issues make laboratory experiences difficult as well. Therefore, it is more expedient and feasible to teach encyclopedic content than provide opportunities for developing experimentation skills and learning practical applications for knowledge and skills in the classroom. Science competitions such as the Science Olympiad provide an extracurricular mechanism teachers can use for engaging students in activities that foster skill development and require practical applications of knowledge-based concepts.

## The Role and Nature of Competitions in Educational Settings

In the latter half of the $20^{\text {th }}$ century, academic competitions were negatively viewed by some (Fülöp, 2009; Fülöp \& Orosz, 2015). At that time competition and cooperation were thought to be polar opposites and mutually exclusive. Fülöp (2009) says, "Related to the tendency to dichotomize competition and cooperation has been the assumption in most of the literature in psychology and education that competition is a destructive force that should be eliminated as much a possible form the environments in which children and adolescents grow. (p. 346). This section of the literature review will look at research concerning the interrelatedness of competition with student behaviors such as academic self-concept,
motivation, intellectual risk-taking, and goal orientations. First, ways in which science competitions are an opportunity to enhance science literacy is promoted. Second, the history of academic competitions and the purposes served are discussed. Lastly, information about interweaving competition with learning and talent development, some of the factors involved, and how competitions can benefit a student is presented.

## The history of competitions in educational settings

Competition in various forms is an ancient perspective. For instance, there is evidence to support that large-scale sporting events occurred as early as 2000 BCE (Verhoef, 1997). Games of skill and intelligence may even predate organized sport. The Chinese game, Go, is thought to have existed prior to 2300 BCE (Verhoef, 1997). In $1^{\text {st }}$ century BCE Rome, the teacher, Marcus Verrius Flaccus, gave prizes to his students for academic competitions and Battista Guarrino, $15^{\text {th }}$ century Italian scholar, wrote that competition stimulated students (Verhoef, 1997).

One of the earliest forms of academic competition in the U.S., the spelling bee, has its roots in $16^{\text {th }}$ century England, though the practice never quite caught on there as it has here. Read (1941) mentions the use of the spelling bee in a Rhode Island school in 1766. He traces the practice to Edmund Coote in England in 1596 (Read, 1941). He quotes Coote, who gave a written description of his method for teaching spelling, "the teacher shall direct his schollers [sic] to oppose one another" (Read, 1941, p. 495). The spelling bee has ebbed and flowed in popularity throughout the years but maintains a place in our culture. The first live broadcast of the U.S. national spelling bee was the finals in 1946. Since 1994, the finals have been broadcast live on either ESPN or ABC with the last six years being broadcast during prime time (National Spelling Bee website) possibly making it the only mainstream prime time academic spectator sport for secondary school students.

While students of the $19^{\text {th }}$ century one-room schoolhouses were spelling against each other in school, they were busy growing crops and produce at home as well. Agriculture and home culture competitions of the $19^{\text {th }}$ century gave rise to the $4-\mathrm{H}$ program. Reck (1951) in $A$ History of 4-H Club Work discusses the history of agricultural competitions. He cites several corn-growing and tomato-growing clubs which held competitions at county and state fairs as forerunners to the later 4-H competitions.

These may seem to be agricultural not academic competitions. Yet, if one realizes that a great part of this competition included the submission of records kept by the participants, it becomes as academic as many present-day competitions (Trace, 2014). The clubs were formed through the schools with teachers or superintendents often serving as the club leaders (Trace, 2014). The clubs continue today as $4-\mathrm{H}$ with being organized through schools (4-H website).

## The history of science competitions

Unlike the spelling and agricultural contests which focused on young people from the start, the science competitions have their foundation in activities designed for adults. The foundation of today's science competitions stretches back to the 1828 Science and Technology exposition held in New York by the American Institute of Science and Technology (Bellipanni \& Lilly, 1999, Terzian, 2008). These expositions were held to introduce science and technological innovation to the public. It is not clear from the literature how competitive these expositions were. However, in 1928, emphasis shifted from an adult-oriented event to that of a fair held for children. The American Museum of Natural History partnered with the Institute in that year to produce what is considered the first student science fair (Bellipanni \& Lilly, 1999; Huddleston, 2014). Fair documents from those early fairs in 1928-1939 show judges reports and lists of winners indicating that these fairs were indeed competitions and not just exhibitions (New-York Historical Society Museum and Library Archives, 2011). In 1939 New York City hosted the

World's Fair and Westinghouse sponsored the American Institute to display exhibits in the Junior Science Hall located in the Westinghouse building there (Terzian, 2008). The American Institute selected for display the award-winning exhibits from its annual Junior Science Fair (Terzian, 2008) which it renamed that year to the Science and Engineering Fair (New-York Historical Society Museum and Library, 2011).

Newspaper executive, Edward W. Scripps and William E. Ritter, a marine biologist from Berkeley, in 1921 formed the Science Service of Washington, D.C. with the purpose of informing the public of the latest scientific breakthroughs (Bellipanni \& Lilly, 1999; Society for Science and the Public website). The Science Service, with the help of G. Edward Ferdrey of Westinghouse, sponsored the first Westinghouse Talent Search in 1942 (Bellipanni \& Lilly, 1999). The 1940's saw these two organizations, the American Institute of Science and Technology and the Science Service join to eventually produce the first national science fair which was held in Philadelphia in 1950 (Bellipanni \& Lilly, 1999; Huddleston, 2014; Murie, 2015). Fourteen years later Seattle hosted the first International Science and Engineering Fair (ISEF) (Bellipanni \& Lilly, 1999). Since 1997, Intel has sponsored ISEF and in 1998 Intel also began sponsoring the former Westinghouse Talent Search. In 2016, the Science Service partnered with Regeneron Pharmaceuticals to sponsor the Talent Search (Society for Science and the Public website).

Between 1970 and 2000, a profusion of diverse academic competitions arose. Karnes and Riley (2013) list 142 academic competitions of which 34 are STEM or have a STEM related component. Some of these various competitions use the term "Olympiad" in their names, such as U.S. National Biology Olympiad and the U.S. National Chemistry Olympiad are discussed in more detail in the section of this paper on the Science Olympiad. Other competitions included

The American Regions Mathematic League Competition founded in 1975; Annual Math League Contests begun in 1977; TEAMS (Tests of Engineering Aptitude, Mathematics, and Science) in 1979; NASA Student Involvement Program (NSIP) established in 1980; MATHCOUNTS begun in 1983; Young Naturalist Award founded in 1998; and Botball Robotics started in 2000. Many of these involve paper and pencil tests, but some require performing some type of building, investigation, or experimentation.

This overview shows that academic competitions in some form have been part of our society since colonial times. Furthermore, many of these competitions still remain part of school life. In rural areas, the spelling bees and agricultural contests and fairs served as community social events (Read, 1941; Reck, 1951) though that is not so often the case now. With the exception of the National Spelling Bee, these competitions receive limited press. Students may go their entire school career without knowledge that these competitions exist unless their school is involved with a specific competition. As mentioned, National Spelling Bee winners often have some press and television coverage, but the "Bee" can be made into a bit of a spectator sport.

## The pros and cons of competition in education

When it comes to academic competition, there is much ambivalence. Many of the objections to competition stem from concern by educators over how students cope with the stresses involved (Fülöp, 2009). Psychology research prior to the 1990's followed the previously mentioned dichotomous assumption that all competition was detrimental, and all cooperation was beneficial (Fülöp, 2009; Fülöp \& Orosz, 2015). However, recent research shows that perceptions of competition are related to that person's coping behaviors (Fülöp \& Orosz, 2015). These topics will be explored in the next two sections.

## Benefits of academic competitions

Some of the benefits found in the literature that can be gained by participating in academic competitions include early talent identification, the gaining of cultural and social capital, formation of the scientific habitus, and overcoming potential Big-fish-in-little-pond (BFLP) effect. These benefits will be explored as they apply to science competitions specifically.

## The role of competition in talent identification and development.

A main purpose of education is to prepare children to enter the workforce. If we do not teach students to compete in school, we are not preparing them to enter a world filled with competition (Ozturk \& Debelak, 2008; Verhoeff, 1997). Such students will experience social inequality in competing within the job market due to a lack of understanding of how to deal with competition. Motivation from competitions can provide strong incentives for students to work hard in order to achieve that competitive level (Ozturk \& Debelak, 2008). However, education theorists are not in agreement on whether competitive desires are something to be promoted or discouraged (Verhoeff, 1997). Proponents of these competitions see benefits to students and society alike. (Campbell and Walberg, 2011; Ozturk \& Debelak, 2008; Verhoeff, 1997). Campbell and Walberg (2011, p 8) list five assumptions under which academic competitions operate:

1) Children with talent need to be identified early.
2) Competitions are needed because many schools do not have the differentiated curriculum or the resources that are needed to challenge extraordinary students.
3) Contests will attract participants with extraordinary talent.
4) Contests will motivate the early development of talent.
5) Once developed, this talent is expected to contribute to society.

Three of Campbell and Walberg's five assumptions deal with talent identification underlying the idea that it is important to identify the talents of students early (Bloom \& Sosniak, 1981; Ozturk \& Debelak, 2008). Several reasons for this exist. One reason lies in the research on positive attitudes toward and interest in science, which declines throughout school up until about age 14 (Archer, DeWitt, Osborne, Dillon, Willis, \& Wong, 2010). Early identification of talents in an area of science and subsequent development for those talents could boost attitude and interest during a time when it would normally diminish. This would help both recruitment and retention in the science fields. Another reason is that the earlier the talent identification, the more time the student has to learn and hone the necessary skills needed to fully develop the talent prior to adulthood and entering the workforce - the more science cultural capital can be accrued.

The idea of cultural capital is embedded in Bourdieu Theory. Cultural capital in one of three forms of capital set forth by Pierre Bourdieu (2002). He states that there are three fundamental guises of capital a person can acquire. They are economic capital, cultural capital, and social capital (Bourdieu, 2002). Though all three are somewhat interrelated, he places cultural capital as being related to the extent to which a person is educated. Cultural capital is defined as those behavior skills and knowledge passed to an individual via pedagogic action primarily by the family (Claussen and Osborne, 2013). This capital is institutionalized by the conferring of educational qualifications on an individual. Families with high cultural capital can begin transmission of the capital at a young age while families with low cultural capital must depend upon others to transmit that knowledge when the child begins school. Economic capital
plays a role in the acquisition of cultural capital in that "...the length of time for which a given individual can prolong his acquisition process depends on the length of time for which his family can provide him with free time..." (p. 284).

Aikenhead (2001a) states that many students enter the science classroom without science cultural capital. Science is to some extent its own culture (Aikenhead, 2001a; Jegede \& Aikenhead, 1999) and a student's entry into science is akin to a cultural border crossing complete with learning of a new language (Aikenhead, 2001a). Science and math both have their own general vocabularies with each field having an even more specific vocabulary. Basic science terminology can be learned in the classroom, but there is little time for field specific knowledge acquisition or learning the processes of a field which is also not the purpose of classroom science. However, learning the processes is an important foundation for scientific thinking and is what Dewey termed as developing "scientific habits of mind" (1910, p. 127). This corresponds to the term habitus in the Bourdieu Theory (Claussen \& Osborne, 2012; Sullivan, 2002). The habitus is defined as the set of practices, attitudes, and values held in common by a social or cultural group. Opportunities for students to explore specialty fields of interest allow them to develop habitus, add to their science cultural capital and ease the cultural border crossing into their field of study when they enter college. The earlier the initiation into the habitus of science can start for the future scientist, the better.

However, as discussed in the Science Literacy portion of this chapter, school science literacy is a literacy-for-all approach and may not be sufficient for the scientifically talented. Many formal academic competitions have long histories as tools for identifying creative and talented students around the world as well as here (Campbell, Cho, \& Feng, 2011). Often students are recruited for these based on grades or other examples of outstanding performance.

This means that competitions could be said not to uncover latent talent in students, but really sorting out those who are already on their way to talent development. In other words, a student's science cultural capital as well as social capital could determine whether or not they are invited to participate in the competition.

Social capital, as explained by Bourdieu (2002), is dependent upon the relationships one has and is in great part tied to the social standing of a person's family. Therefore, a student can have school social capital which is somewhat based on school social structure from things like who your family is to being a star athlete. School social capital also plays a role in what classes students choose to take and therefore, can impact the amount or type of school cultural capital they gain during their years of school. Science competitions offer science students an opportunity to gain school social capital. In the "jock versus geek" subculture, this social capital may not be as valuable when "cashing in" for social standing with peers as that acquired by the athlete. However, it can have a high value with teachers which can influence a student's choice in classes if one feels more comfortable with or encouraged by a certain teacher. In science education, a rapport gained with science teachers through the competition experience can make a student more comfortable enrolling in elective science courses. The social cultural capital the student has with the teachers gives one confidence in being able to ask for assistance in classwork and thereby increases the level of academic risk or intellectual risk taking (IRT) the student is willing to take (Beghetto, 2009). This improves chances of greater talent development by the student and can result in the student gaining more science cultural capital by the time of graduation.

One major component of how much a person enjoys a game and how willing one is to compete is the level of risk in which that person is willing to engage. Intellectual risk taking (IRT) is where a person uses adaptive learning behaviors in an academic decision situation for
which the probability of success or failure is uncertain (Beghetto, 2009; Clifford, 1991). Research has sought to explore factors that might influence a person's willingness to engage in IRT. Many behavioral theories have been applied in the effort to isolate factors and identify interaction. The results of the early research studies by development theorists identified freely chosen optimal challenges as good motivators for learning achievement (Clifford, 1991). This is in line with Vygotsky's Zone of Proximal Development, which states that one can promote learning and cognition development by assigning challenges just above the students' current level (Beghetto, 2009; Clifford, 1991). In-classroom or in-school competitions done as a game time or fun time activity can serve as a means for talent identification. Using informal competitions is a better choice to identify actual interest and talent than relying on grades. This is because sometimes students are willing to take intellectual risks if they perceive the activity to be separate from a class (Beghetto, 2009).

Informal game-type settings provide low-pressure competition opportunities where IRT is safer because it is not connected to a grade. If one makes a mistake in front of one's peers, it is likely to be laughed off during a game with maybe some minor teasing. In addition to lesser consequences for looking foolish in front of one's peers, there is also less feeling of garnering teacher disapproval for mistakes when it is all fun. Therefore, the consequences are less. This indicates that failure tolerance is higher for games than for schoolwork (Clifford, 1991).

Another benefit of competition for talented students, especially in small schools, is in overcoming the Big-fish-little-pond (BFLP) effect. The BFLP model states that students will compare themselves to their immediate peers to develop their academic self-concept (ASC) (Nagengast \& Marsh, 2012; Wouters, Colpin, Germeijs, \& Verschueren, 2009). This may lead to formation of a false appraisal of one's abilities by having too small a set of references. A
student of moderate ability in a low performing class or school may overestimate actual abilities. Likewise, a moderate student in a high performing school may underestimate their actual ability. Both types of students can benefit from competition. The student of moderate ability in a low performing class will likely need mentor support in facing the realization that there are many able students out there. Mentor support can help this student learn how to increase ability and further develop talents. The experience can motivate the student to overcome complacency and establish a new basis of comparison. Hopefully, this supplies incentive to increase science interest and achievement.

The moderate student in a high performing school may suffer from low self-esteem and low ASC because of constant comparison to higher performing peers. This student is at risk of not choosing a science career despite having adequate ability (Nagengast \& Marsh, 2012). A mentor can lead this student to find the niche in which his or her science interests and talents lie and where the student may achieve success. Entering in a competition for this niche area can allow the student an opportunity to show that he or she is not average and can introduce the student to others with similar interests. Ideally, the science competition presents students in either of the situations with opportunities to choose or develop an optimal challenge for themselves.

The most important of benefits to students according to research are fun and learning new things (Abernathy and Vineyard, 2001; Wirt, 2011; Schmidt, 2014). Competitions are fun. Interviews of students from spelling bees to various science and math Olympiads to science fairs show that fun is a central motivation for continuing to participate year after year. Wirt (2011) studied the benefits that participants perceived they gained from being on a Science Olympiad team. The study found that participants frequently mentioned the social aspects of being
involved. Of these social aspects, respondents mentioned fun as the major benefit of participating. In the study by Schmidt (2014) qualitative analysis of comments regarding attitude toward science revealed that students thought Science Olympiad made science more fun. Abernathy and Vine (2001) noted comparable results. In their study of 453 Science Olympiad participants, these individuals chose from a list the three best reasons for participating in the Science Olympiad. Fun ranked as the primary reason for participating.

After fun, research shows learning new things ranked second in items on the list from Abernathy and Vine (2001). Wirt's (2011) study investigated participants' perception of their learning while involved in the Science Olympiad. The responses revealed that some students felt that they learned more while immersed in the Science Olympiad activities than while in a regular classroom. This is supported by comments in the qualitative portion of Schmidt's (2014) study where students stated that they enjoyed being challenged by material above the level of that in the classroom and being able to study a topic in greater depth.

## Addressing the concerns about academic competitions.

There seems to be very little negative in competitions. This may be due to the fact that many academic competitions are voluntary. The most common objective to academic competition from education researchers is a concern about how students will deal with stress and potential disappointment in the outcome of the competition. The way in which a student handles the competition experience can be influenced by several factors including type of achievement goal orientation, motivation type, and self-concept.

Achievement goals can be divided into four orientations - learning, work avoidance, performance approach and performance avoidance. Learning goals refer to acquiring new knowledge or skills (Höffler et al, 2016). Students who increase competencies such as learning to build an object that can accomplish a task or learning to identify birds will consider they have
achieved success (Spinath \& Steinmayr, 2012). Students with work avoidance orientation will apply the minimal effort required for an achievement related task (Höffler et al, 2016). Performance approach-oriented students want to demonstrate their competence to feel successful (Höffler et al, 2016; Spinath \& Steinmayr, 2012). While performance avoidance-oriented students simply want to not demonstrate incompetence (Höffler et al, 2016; Spinath \& Steinmayr, 2012). Obviously, the performance approach-oriented students should be easily attracted to competitions since it gives them a venue to demonstrate competence. However, there may be concern for this group because of the potential for damaged egos if they fail to demonstrate that competence. Additionally, learning goal-oriented students may also benefit from competition. This student type may be best exemplified by the spelling bee finalists (Kronholz, 2010) who did not win and stated that they would resume studying and do better next time. The same can be seen in science fair participants who will learn from the process and come back with a more competitive project each year and Science Olympiad students who will improve in their events between tournaments. Work avoidance and performance avoidanceoriented students are possibly not best served by competition venues. However, research indicates that people can possess multiple goal orientations which interact (Jowkar, Kojuri, Kohoulat, \& Hayat, 2014) and that students can be guided to some extent in the types of goals they set.

An often-mentioned negative concept of academic competition is feared damage to selfesteem. The thought is that those who do not win in an academic competition would come away with lower competence beliefs resulting in loss of self-esteem. This in turn will cause students to withdraw effort in that area (Jowkar et al, 2014) and to not engage further in that area of intellectual risk taking (IRT). Again, research on achievement goal orientation shows that this
effect is not as great as feared or can be ameliorated by a coach or mentor. Interestingly, goal orientation has failed in several studies to produce effects for IRT. Instead, findings show that the level of IRT engaged in relates to the level of expected benefits to be gained (Clifford, 1991). So, perhaps like risks in nearly every other area of life, intellectual risks are calculated against pay off. Perceived pay off or gains can be a factor of motivation.

This type of motivation that is driven by a pay off or external reward is also thought to be the type that would cause one to desire competition and is termed extrinsic motivation. Extrinsic motivation has been defined as the desire to engage in an activity as a means to an end and not because one enjoys the activity itself (Orosz, Farkas, \& Roland-Levy, 2013). Thus, the belief existed that participants are only after the reward in the competition. Some education researchers deemed this an undesirable characteristic in students and suggested it be discouraged. If someone enjoyed an activity, they would engage in it for the pleasure (intrinsic motivation) and not care about competition. It was also thought that extrinsic motivation and intrinsic motivation were mutually exclusive. Intrinsic motivation is defined as coming from within the student (Ozturk \& Debelak, 2008) and is when the focus is placed on the process of doing rather than the outcome (Orosz, Farkas \& Roland-Lévy, 2013).

Using MathCounts as an example, Ozturk \& Debelak (2008) offer another view and describe how competitions can offer both intrinsic and extrinsic motivations. Kuech and Sanford (2014) suggest that extrinsic motivation may be a good starting point from which students can progress into doing science for the joy of it. Both Verhoeff (1997) and Ozturk and Debelak (2008) refer to sports as an example of where participants have the extrinsic motivator of a desire to win, but also the intrinsic desires of engaging in the activity and improving one's skills. In sports, it is the coach who directs the students to keep the desire to win, but to focus on
building abilities (talent development). The same applies to academic competitions. The academic competition coach is responsible for focusing the student on building the necessary skills to reach both the personal growth and the tangible reward goals.

Skill improvement leads to perceived self-competence related to those skills and is important in building a healthy self-concept (Kuech \& Sanford, 2014; Ozturk \& Debelak, 2008). Motivation, dealing with a competitive world, and a healthy self-concept are three of five affective benefits Ozturk and Debelak (2008) described for competition. The other benefits include coping with subjectivity and interacting with supportive role models (Ozturk \& Debelak, 2008). Learning to cope with the judges' decisions when one does not necessarily agree is a valuable life lesson for students in that actual or perceived unfairness is an inevitable part of many decisions that will affect their lives (Ozturk \& Debelak, 2008). It is important part of education for students to gain coping skills. Fülöp and Orosz (2015) describe three coping behaviors as 1) balanced, 2) narcissistic-dominant-aggressive, and 3) avoidant-giving up. The literature indicates that educators fear that many students possess the third coping behavior (avoidant-giving up) and will turn away from science after their first negative experience in a science competition. A supportive role model or mentor is helpful in guiding a student through these types of psychological and emotional challenges of competition.

Competitions can offer positive experiences depending upon how a person deals with the outcome. Therefore, it is the mentor's job to identify the initial interest (talent) and direct the student toward setting realistic learning goals. As Spinath and Steinmayr (2002) state, "Initial interest might foster a learning-goal perspective, and a learning-goal perspective might, in turn, foster subsequent interest" (p. 1145). Everyone can achieve realistically set learning goals from participating in a competition regardless of who wins. A mentor can reduce the impact a student
might feel from a competition loss by helping to frame how the student views the other competitors. Viewing another competitor as a friend, active partner, motivator, or comparative other can put results into a more positive and constructive light than regarding the other as an opponent or enemy because the former is associated with emotions such as love and respect while the latter are associated with hatred and fear (Fülöp \& Orosz, 2015). Individual academic achievement has been shown to have a positive effect on academic self-concept and career aspirations (Nagengast \& March, 2012). Sometimes, just having someone in authority tell you that you are capable is enough to make you try to discover your own talents.

## The Role of Competition in Enhancing Science Literacy

Students who are involved in competitions seem to be more excited about coming to school (Toppo, 2016). Teachers reporting to county agents on the Corn and Tomato Clubs noted that girls involved in the Tomato Club showed greater interest in schoolwork generally (Reck, 1951). The increased interest in school in general and the ability of seeing an application for at least part of what is being learned increases interest in learning. As was noted by Shamos (1995), literacy is often not developed until the person sees the need for literacy. Involvement in academic competitions reinforces the need for both general literacy and the specialized literacy for the area of competition. As has been previously discussed in this section, the necessary habitus for future scientists can be enhanced through participation in science competitions. The mastery of many Next Generation Science Standards (NGSS) performance expectations through participation in the Science Olympiad is discussed in the Science Olympiad section. Similar connections could be made to many of the other Olympiads as well as the competitions mentioned in this section.

## The Development and Roles of Several STEM Olympiads

The term Olympiad is a general term applied to a wide range of academic competitions in different disciplines. The term is typically capitalized when found in the literature so that tradition will be continued here. These varied competitions encompass the areas of science, technology, engineering, and math (STEM). The first use of the term for academic competitions was for a series of mathematics examinations given in the Soviet Union in 1934 (Campbell, Cho, \& Feng, 2011; Campbell \& Wahlberg, 2011; Karp, 2002). The competition extended internationally in 1959 (International Mathematical Olympiad website). The Physics Olympiad formed later based on the math model (Eisenkraft \& Kirkpatrick, 1992) followed soon by the Chemistry Olympiad in Germany (Urahne, Ho, Parchmann, \& Nick, 2012). These constitute the big three of international science-focused Olympiads as far as prestige and amount of coverage in the literature. Other international Olympiads in additional STEM fields have appeared more recently as well as various regional and local Olympiads not connected to each other or to national or international competitions. While the big three focus on one specific STEM field, other Olympiads offer a variety of formats in which participants compete. Of course, the Science Olympiad is the particular Olympiad of interest in this study. It differs from the big three and others in several ways which will be explored in this section.

## History of Science Olympiads.

## The Math Olympiad.

The Mathematical Association of America (MAA) was founded in 1915 as an association to sponsor the publication American Mathematical Monthly. The MAA was founded with the focus of supporting the teaching of mathematics. The MAA sponsors four levels of competitions for secondary school students which can ultimately lead to selection for the U.S. team to attend the International Mathematical Olympiad (MAA website). The purposes of this competition are:

- To promote the development of problem-solving skills
- To develop positive attitudes towards analytical thinking and mathematics that can assist in future careers
- Students apply classroom learned skills to unique problem-solving challenges in a low-stress and friendly environment.


## The Chemistry Olympiad

In 1983, a task force of the American Chemical Society (ACS) Division of Chemical Education recommended that a national competition be held to select a US team to compete in the International Chemistry Olympiad to be held in Frankfurt, Germany the following year (Davis, Ragsdale, \& Zipp, 1989). The ACS thus began and sponsored the first U.S. National Chemistry Olympiad (USNCO) in 1984 (American Chemical Society (ACS) website). Students begin by participating in a local Chemistry Olympiad. Students are then nominated to take the U.S. National Chemistry Olympiad Exam. The twenty top scoring students from this exam are invited to a two-week camp at the U.S. Air Force Academy. Through a combination of objective and subjective evaluation during the camp four students are chosen to represent the U.S. at the International Chemistry Olympiad (IChO). The purposes for this competition are to:

- Stimulate young people to achieve excellence in chemistry
- Recognize outstanding chemistry students and, in doing so, encourage additional learning at a formative time in their intellectual development
- Recognize the excellent achievement of teachers and the importance of the school environment
- Provide contact between ACS local sections and area schools and foster interest among professional chemists in teaching chemistry
- Challenge the chemical knowledge and skills of young students in an international arena
- Foster cross-cultural experiences and acquaint students with similarities and differences between themselves and their counterparts from other nations
(ACS website)


## The Physics Olympiad.

The American Association of Physics Teachers (AAPT) and the American Institute of Physics (AIP) sponsor the United States National Physics Olympiad (USAPhO). The first team was assembled in 1986 based on teacher nominations but team selection is now exam based (American Association of Physics Teachers (AAPT) website). The AAPT is responsible for selecting and training the U.S. team. The Olympiad consists of two levels of exams. The participants with the top twenty scores on the USA Physics Olympiad Exam are invited to the U.S. Physics team training camp for a ten-day intense training program. At the end of this program, five participants are chosen to represent the U.S. at the International Physics Olympiad ( IPhO ). The purposes of this competition are to:

- Encourage excellence in physics education and to reward outstanding physics students
- Expand awareness of and participation in the program
- Provide a meaningful scientific and cultural experience for team members, including opportunities to network and meet new people, learn in intellectual and experimental ways, and gain international exposure
- Win medals and compete successfully on an international level


## (AAPT website)

## Science Olympiads and Future Scientist Development

The team approach of the Science Olympiad which encourages participation in multiple categories differs from the standard individual participant focus in a single category of the science fair competitions or the individual emphasis of the big three Olympiads. However, the big three are focused more on finding the best of the best and developing those students to become national and international leaders of the discipline. Campbell and Walberg (2011) examined the assumption that competitions will help identify extraordinary talent and once identified, these talented individuals will be developed to contribute to society. They analyzed 345 adult former participants in the big three Olympiad U.S. team selection competitions (AMO, USAPhO, and USNCO). The researchers found that over half of these participants had earned their doctoral degrees and pursued careers in technical areas which the authors felt did contribute to society. To support this statement, they reported that these professionals had collectively published a total of 8,629 publications as a measure that they were indeed contributing to new knowledge.

STEM educators are interested in the role that science competitions such as the Science Olympiad play in students' choice of a STEM field as a career (Campbell \& Walberg, 2011; Gordeeva, Osin, Kuz'menko, Leont'ev \& Ryzhova, 2013). Sahin (2013) studied the STEM matriculation percentages of students at one charter school system serving approximately 20,000
students. The study included students in Science Olympiad as one of the seven after school STEM-related activities in which students could participate. The study found a relationship between the number of STEM clubs a student participated in and the likelihood that a student would choose a STEM major in college or if they graduate college with a STEM degree. The question here is whether participation in these clubs increased this any or if those students were going to major in a STEM career anyway. The practice of teachers encouraging students whose science interests and talents are already evident means that the best this statistically significant relationship can show is that it may have retained some students' interests and made them feel that they had a home in science, but we cannot say that it caused the students to select a STEM major.

In a study of 635 current and former Science Olympiad competitors, Wirt (2011) identified long-term effects of Science Olympiad involvement. One of those effects was that most of the adult and college age former participants were either pursuing a degree in or already engaged in a STEM field. These former participants felt that Science Olympiad had influenced their career choice.

Schmidt (2014) studied seventh graders on Science Olympiad teams from five different schools and using quantitative analysis of responses to a science opinion survey found no evidence to support that participation in science competitions increased middle school student interest in STEM careers. However, analysis of data from focus groups comprised of students selected from the same teams indicated that students believed Science Olympiad participation caused them to consider a science career for the future. So, the purpose of these competitions may not be as much a recruitment tool as they are an affirmation system.

Some studies have focused on the relationship between gender and SO competition. Stringer, Mace, Clark, and Donahue (2019) investigated the changes over time between participants in one of three STEM competitions and non-participants in their STEM identity and motivation. They found gender differences in that fewer girls competed and that girls suffered greater decline from middle school moving into high school in STEM career identity and science motivation than boys. However, the decline was reduced in girls who competed in the STEM competitions when compared to those who did not. A study of 694 middle school and high school Science Olympiad participants by Wood (2020) looked at gender differences in event selection as well as female STEM identity and female STEM self-concept. The study found that both of these factors decline from middle school to high school and are lowest for females in Physics and Technology \& Engineering related fields.

The many categories of the Science Olympiad allow opportunities for students of various interests to find their niche. Each year the competition presents 23 distinct events for the teams to enter. The mix of these events change each year. Tables in Appendix D and Appendix E list the events of the categories offered each year since 2008. There are approximately seventy possible events for the junior high (Division B) competitions and approximately sixty possible events for the senior high (Division C). Each year about half of the categories change so that some of the events have a rotation of three years on and two years off or two years on and two years off. Others are rotated based on the balance they bring to the offering in meeting the distribution previously described for spreading the events across the three broad areas of the NGSS. A state director informed the researcher that some of these events may never be used again once they are dropped off and new ones can be developed and approved, so these events are not set as the only possibilities. The tables reveal certain events that are consistently part of
the competition. The explanation for this is that those events are incredibly popular with the participants and the directors see that the participants are getting value in one or more ways from them (personal communication with State B director, February 22, 2020).

## Chapter Conclusions

Science Olympiad participation allows students opportunities to develop literacy in the area or areas of specific personal interest and to progress over a course of several years along that continuum at a rate that fits the student's ability and passion. Competitions can support science education in several ways. Informal in-school competitions can reveal latent abilities or interest that might not be reflected in grades or other classroom activities. This is a stated goal of the Science Olympiad (Science Olympiad website) as was stated previously. More formal intermural science competitions can provide students with direction for goal setting and motivation to develop science skills beyond the demands of the school curriculum or in areas of interest not addressed in the school curriculum. Successes in achieving learning goals and the inspiration gained through interacting with other people with similar interests can solidify a student's resolve to pursue a science career.

As stated in the competition section of this chapter, Science Olympiad participation is not for every student. It is a place to allow those with talent and desire to explore areas of interest and find or cultivate their passions. A place where they can go beyond the teachings of the classroom. Most of all, being part of a Science Olympiad team provides students with a place they can belong and interact with other students having the same or similar interests. It allows opportunities to travel and meet students with the same interests outside of the school. Successes in the Science Olympiad can serve to affirm to the student and their community that they have competency and ability in the area of their interest. This affirmation can increase support from those around them and enable them to pursue their passion. The Science Olympiad offers
students many paths to prepare for future STEM careers. In doing so, it allows for development of science literacy in each participant in a way that is personally meaningful and compelling. It allows learning to be fun again.

## Gaps in the Literature

Science Olympiad research has mainly focused on the students with little to no research on coaches. The focus on the students has also been mostly on the effects of participation on career choice as has been previously discussed with the research by Wirt (2011), Sahin (2013), Schmidt (2014), Stringer et al. (2019), and Wood (2020). One study deviated from a focus on student career choice and looked at usefulness for science instruction. McGee-Brown (2014) conducted a three-year longitudinal study of the Georgia Science Olympiad and concluded that Science Olympiad competitions could motivate students in gaining science, engineering and mathematics skills and knowledge (McGee-Brown, 2014). Also, as previously mentioned, several of these studies in looking at student attitudes have determined that a main factor in participation is fun.

Two studies have focused on Science Olympiad alignment with standards. Patterson (2018) compares middle school SO events with the Tennessee Science Curriculum standards. The study found that all middle school events could be used to teach one or more standards for that state suggesting the same could be true for other states. Meadows and Caniglia (2018) analyzed both middle school and high school events against Common Core State Standards in Mathematics (CCSSM) using Webb's Depth of Knowledge Levels (DOK). They found a significant number of SO events were aligned and had high levels of DOK within both Division $B$ and Division C events.

Only one study of the motivations of coaches for participation was found in the literature. Robinson (2003) interviewed nine coaches to find out why they volunteered and found that it
was because they enjoyed the experience. Another coach focused study was a single case study of a coach who had led his team to six consecutive national championships. Kulbago (2016) used the coach-athlete relationship model to analyze this coach's personal coaching approach and found three emergent themes: structure, relationships, and expectations. Kulbago (2016) proposes that these factors may be useful in describing the necessary components of a successful academic competitive team program. This study did not look at coach motivation.

This study adds to the current literature by enhancing understanding of why adults volunteer to mentor students in Science Olympiad. This was accomplished by asking for descriptive details of their experiences that might identify and further define what it is that motivates them. This study will also look at coach opinions about perceived gains by students in science knowledge from Science Olympiad participation. The Phase I data was obtained through an open-ended questionnaire that allowed for a freedom of response that could reveal unexpected areas of learning beyond what has been noted in previous studies. Phase II followed with personal interviews to further explore the experiences related by twelve coaches. This study compared the themes that emerged back to the various definitions of science literacy presented in this review as well as to the stated goals of the Science Olympiad.

Questionnaire items also delved into the different types of support that students and coaches receive from various sources in their school and community. This yielded insight into social views of academic competitions and further enhanced the understanding of the experience for the student and coaches. Finding of this study aid in understanding the challenges that teams have to overcome as well as illustrates the role school and community support plays in the life of a team.

## Chapter Three - Research Method

## Introduction

This chapter describes the nature of this study, how the participants were recruited and how the questionnaires and interviews were developed and administered and how data were analyzed.

Science Olympiad research focusing mostly on benefits to students has not given much information on why coaches choose to participate in what is typically a voluntary activity that often does not carry with it a stipend or other form of additional pay. This study explores the experiences of coaches as related through descriptive responses to questionnaire prompts and an interview to reveal what attracts coaches to participate in this competition.

## Research Questions

Research Question 1: According to coaches and, what knowledge, skills, and personal growth opportunities does Science Olympiad provide?

Sub-Question 1A: What experiences in these regards do coaches see students having?

Sub-Question 1B: What experiences in these regards do coaches relate as personally applicable about their work in Science Olympiad?

Research Question 2: What are the challenges/barriers to Science Olympiad participation?

## Nature of the Study

The purpose of this study is to explore the experience of participating in the Science Olympiad. Specifically, this study seeks to identify opinions and attitudes held by coaches regarding aspects of participation experienced by them and what they perceive their students experience resulting from that participation.

This is a hermeneutic phenomenological study utilizing naturalistic investigation which uses purposive sampling and case study design. Purposive sampling means that the researcher has a purpose in mind when selecting subjects and that they are not random (Lincoln \& Guba, 1985). The purpose of this type of sampling is to reveal as much varied information as possible. This means that it is difficult a priori to know what the sample will look like.

## Subjects

The focus of this study is on coaches of teams from schools located in two west south central states and two west north central states. The researcher chose this section of the United States because it is the region in which she resides, and she is personally interested in actions that could increase participation in science competitions in this region. Currently there are 446 teams competing in the four target states (http://www.soinc.org). One school system may have as many as three high school teams, three middle school teams, and any number of elementary teams. Elementary teams were not included in this study. The states were given letter designations to help further ensure anonymity of the participants.

The first phase of the study sought to involve coaches from as many of the teams in the region as would respond. There were 34 coaches responding to the questionnaires. Those coaches whose responses to the completed questionnaires were detailed, different, unexpected and/or seemed to warrant more explanation were asked for interviews. Yin (2018) recommends using a screening procedure of potential candidates for interviews to narrow the number of candidates for case studies to twelve or fewer. Hatch (2002) in his book uses an example study with 6 case studies. Erlandson et al (1993) say, "The basic rule is, 'There are no rules for sample size'." (p. 83)

Nine coaches responded to the interview invitations, but three did not follow through with scheduling interviews resulting in only six participants. Since this was a small number, the
questionnaires were reexamined to include a few more coaches who were not initially invited as well as some additional coaches personally recommended by the state C director and some additional coaches personally recommended by a coach in state B. Also, several who had not responded to the first invitation as well as the three coaches who had not been able to schedule interviews were extended a second invitation. This second round of invitations resulted in eight responses and yielded six additional interviews. This gave a total of twelve interviews for the study. The coaches in this study lead diverse teams that range from those that win or take runner-up in their state every year to teams that struggle to compete at an invitational. (An invitational is a practice tournament where a host school invites other schools to compete to gain practice before an official regional or state competition.) Four coaches were from State A. State B was represented by 3 coaches as was State C. Two coaches had teams in State D. Due to the uniqueness of their situations and experience, each coach was considered an individual case. Having a case number of twelve aligns with the literature for exploratory studies (Yin, 2018).

The participants in the interviews had diverse histories with Science Olympiad. There were coaches who coached only middle school, those who coached only high school, those who coached both simultaneously. Some coaches were at small rural schools while others were at larger city schools and some were at private schools. Most of the coaches had coached at a small school previously if they were not currently at one. Two of the coaches interviewed began their Science Olympiad career as students, became volunteer coaches for middle school as adults, then coached later as teachers at the high school level, and, at the time of the interview, one of these two was Science Olympiad director for her state. Another coach was also not a teacher but had coached for many years as a community volunteer. Two other coaches were teachers, but not of science or math. One of these had taken her middle school team to Nationals
multiple times. One of the small school coaches was chosen specifically because she sounded frustrated and discouraged and the researcher wanted to explore that perspective to place beside the more enthusiastic responses from other coaches. The school demographics ranged from small rural to large urban and are given in Table 1. Since most coaches had coached at more than one school and mentioned those schools in the interview, the demographic for each school is given under the coach's pseudonym. This diversity is desirable for this type of study because it will enhance the range of descriptions for this experience. The choice to include both middle school and high school coaches for participants was necessitated by the knowledge that there are more middle school teams than high school teams and that to get a good number of returned questionnaires, it was important to not exclude part of the population.

## Specific Research Procedures

The questionnaire invited the participants to describe their experiences with various processes and activities they encounter as part of their Science Olympiad participation. The first step was to gain access to the potential participants of the study. The researcher contacted the national headquarters of the Science Olympiad to request a list of coaches in each state. The national organization responded that the researcher needed to contact the director in each state to request that information. Contact information for state directors is available on the SO website. The director of each state was contacted by email and provided with a copy of the introductory coaches' letter (Appendix F) requesting volunteers and asking the state directors to provide contact information for the coaches in their state or to forward the coaches' letter to their coaches. Two state directors responded immediately that they were putting my request out to all the coaches on their email list. One of those directors knew the researcher personally and also added her onto that state's email group so that she could post requests and information directly to the group. Two other state directors were unresponsive. Several coaches from the first two
states contacted me with interest in participating in the study. Further attempts to contact the second set of states revealed that the researcher had erroneous or outdated contact information. Eventually, the researcher did make contact with one of those state directors who responded that they were also forwarding the request to the coaches in their states. No coaches from that state contacted the researcher following this. Meanwhile, in the first set of states, the researcher only received one completed questionnaire. The researcher followed up with these other coaches who had expressed interest. Several coaches suggested that the researcher come to a meet and observe. At this point that year's tournament season was nearly over, but State C still had their state meet left. The researcher attended that meet and made a presentation introducing the research at the awards assembly. Several coaches indicated interest and took questionnaires. Most did return the questionnaires via email in the weeks following the state meet. In the following fall, emails were again sent out asking the coaches to respond. The researcher received no new responses. The State C director suggested the researcher attend an invitational meet that fall and personally ask the coaches to fill out the questionnaire during the day and turn it in while there to avoid good intentions getting lost in procrastination or being forgotten. The researcher took up the offer and attended two meets in that state. While there, the researcher met a coach from each of the two states where the directors had not responded to the original email, and it was here the researcher discovered that she had not been contacting the right people for those states. Each of these coaches invited the researcher to upcoming invitational meets that they were holding at their schools. The researcher attended one of these in State A and the other in State B was cancelled by the school due to unforeseen circumstances. The personal approach did provide a greater number of returned questionnaires in States $\mathrm{A}, \mathrm{B}$, and C . At the invitational in State A, the researcher was introduced to the State A director and that helped in making
contact later via email with coaches in that state that were not present at that invitational. The coach whose event was cancelled was in State B and he put the researcher in contact with several coaches from his state. He explained that his state was in transition between directors and that was why there was an issue with contacting through that route. In all the in-person approach was the successful one and even then, about one third who said they were interested did not return a completed questionnaire at the end of the day. It was equally difficult during Phase II to obtain interviews from those who had returned questionnaires.

The first phase consisted of a qualitative exploration of the Science Olympiad experience in which opinions and attitudes about participation were collected via an open-ended questionnaire from Science Olympiad coaches at different participating schools in the target region of Arkansas, Kansas, Missouri, and Oklahoma. Texas was added later when it was discovered that several of the coaches returning questionnaires at an Oklahoma meet were from Texas. Two of these coaches responded to interview requests. One Arkansas coach responded to the email request for questionnaires but did not respond for a follow up interview. Therefore, Arkansas is not represented in the cases reported in this study. The responses to these instruments were used to develop questions for the coach interviews and to select the coaches who would be asked to give an interview. The second phase consisted of the interviews. Coaches whose answers to questionnaire items contained a lot of detail or gave interesting answers that made the researcher think that coach possessed a lot of knowledge to give were invited to participate in an online interview. A total of twelve coaches agreed to the interviews.

## Data Analysis

The data from the coach's questionnaires and follow up interviews was analyzed using qualitative methods. Percy, Kostere, \& Kostere (2015) recommend three types of analysis for qualitative research. These are inductive analysis, theoretical analysis, and thematic analysis
with constant comparison. Hatch (2002) describes five models for qualitative analysis: typological, inductive, interpretive, political, and polyvocal. Inductive analysis is used when there is no attempt to fit data into preexisting categories (Hatch, 2002; Percy et al., 2015) and bears a strong resemblance to interpretive phenomenological analysis (Lincoln \& Guba, 1985; Smith and Osborn, 2007). The inductive analysis approach is to search through the qualitative data for patterns and themes across the individual responses without having preconceived categories for those patterns or themes (Hatch, 2002; Patton, 2015). Using preexisting categories would indicate a type of analysis called theoretical analysis by Percy et al. (2015) or typological analysis by Hatch (2002).

Since the purpose of this study was to reveal previously unknown themes in coaches' experiences using a hermeneutic phenomenological approach, there were no preconceived categories in which to sort data. Therefore, data was analyzed to find emergent themes. Lincoln and Guba (1985) state that the inductive analysis process is well suited for the emergent design. Lincoln and Guba (1985) and Erlandson et al. (1993) recommend constant comparison as their method for inductive analysis.

Constant comparison can be simply described as finding the categories in the first piece of data, finding the categories in the second piece of data, and then comparing the second set of categories to the first set. This process continues for all data pieces (Percy et al., 2015) and allows the themes to emerge out of the data. This also supports the idea of emergent design in that the themes and patterns found will suggest further investigation and, in the case of grounded theory, will suggest the theory explaining the phenomenon. Percy et al. (2015) calls this method "thematic analysis with constant comparison" (p.83) and refers to a detailed method developed by Glaser \& Strauss. An abbreviated and modified description of the steps follows:

1. Researcher will read each participants data individually. Any sentences, phrases, or paragraphs that appear meaningful will be highlighted.
2. The highlighted data will then be reviewed to determine how it relates to the research question.
3. All non-relevant highlighted data will be moved to a separate file.
4. Each piece of remaining data will be coded.
5. Related or connected items of data will be clustered to begin development of patterns. Discernable patterns will be described in a summary phrase.
6. When this process is completed for the first participant's data, each subsequent participant's data will be analyzed in the same manner and compared to the previously analyzed data.
7. As patterns emerge, items will be moved into the clusters for the pattern with which they correspond.
8. Any overarching themes in the patterns will be sought.
9. Patterns and themes may shift as comparison progresses.
10. After all data analysis is complete, the themes will be arranged with their corresponding patterns so that supportive layers can be easily identified for discussing individual themes.
11. A detailed analysis will be written for each theme describing its scope and substance.
12. Themes will then be synthesized to form a composite of data for each research question.

Hatch (2002) states that very few researchers carry out this process to the extent intended by Glaser \& Strauss. He gives a slightly different set of steps which provide the guideline for analysis used in this study. His steps of inductive analysis are:

1. Read the data and identify frames of analysis.
2. Create domains based on semantic relationships discovered within frames of analysis.
3. Identify salient domains, assign them a code, and put others aside.
4. Reread data, refining salient domains and keeping a record of where relationships are found in the data.
5. Decide if your domains are supported by the data and search data for examples that do not fit with or run counter to the relationships in your domains.
6. Complete an analysis within domains.
7. Search for themes across domains.
8. Create a master outline expressing relationships within and among domains.
9. Select data excerpts to support the elements of you outline.
(p. 162)

Yin (2014) states that there are four tests commonly used to assure the quality of research design. They are construct validity, internal validity, external validity and reliability. This study used a multiple case study design with converging evidence from two souces per case. Data in the study was obtained from an open ended questionnaire followed by a semi-structured interview to build individual cases for each coach participant. The use of these two sources as well as member checks by each participant of their own case study draft enhanced the construct validity of this study (Erlandson et al., 1993; Yin, 2014;).

Internal validity for an exploratory study is different from studies trying to show causality (Yin, 2014). This multiple case study used cross-case synthesis comparing within-case experiences across all the cases and finding themes of similar experiences. Contrasting rival experiences when they occurred also served to enhance internal validity.

External validity refers to whether the findings of a study are generalizable beyond that study (Yin, 2014). As previously stated in Chapter 1, the purpose of hermeneutic phenomenological studies is not to produce generalizability (Van Manen, 2010). Lincon and Guba (1995) recommend focusing on the transferability of case study findings. The use of multiple case studies and looking at commonalities across cases indicate that the finding here may be transferable to the experiences of other Science Olympiad coaches in similar contexts. Erlandson er al. (1993) state that transferability is achieved when the context being transferred to has shared characteristics with the original context. This judgement can only be made by the reader who is in the second context. Therefore, the report must contain sufficient detail and description to allow judgments by the reader regarding similarity of contexts.

Reliability and dependability are addressed by Erlandson et al. (1993) as interchangeable terms. It is the consistency of the study (or instrument used) and the evidence that the study could be replicated with the same or similar participants. Reliability in this study was maintained procedurally by using the same set of semi-structured interview questions with each participant. Conversations during individual interviews may have resulted in certain topics being more explored with some participants than with others, but all questions were asked of each participant.

## Chapter Four: Results- Cross Case Analysis

## Introduction and Organization

This chapter features data from the interviews of twelve Science Olympiad coaches. The responses from six coaches who answered questionnaires were collected at three different Science Olympiad tournaments (or "meets" as they are sometimes called) and agreed to individual online interviews held after the Covid -19 prematurely ended the 2019-2020 season and six coaches who answered questionnaires via email and agreed to online interviews during Spring 2022. A brief profile of each subject is provided in Table 1. Subjects were assigned pseudonyms to protect their anonymity. Individual Case Studies are in the Appendices.

## Science Olympiad Coaches in this Study: An Overview

As may be seen in Table 4.1: the coaches in this study are current coaches (with the exception of the state C director who last coached six years ago) for either middle school (Division B) or high school (Division C) teams. Some coaches have experience with both divisions, and one had experience with an elementary team (Division A). Two coaches participated in Science Olympiad as students, and one is currently a state director. One coach is not a teacher but is a volunteer not employed by the school. Another coach is a homeschooling mother who voluntarily runs a team for other homeschoolers in her two-county area. Five of the teachers relate experiences coaching teams from private schools. Five other teachers discuss coaching at public schools.

Several of the coaches talked about past coaching experiences as well as their present school and made comparisons between their experiences at the different locations. The demographic information for each school is the most current information available from the National Center for Education Statistics website at the time of the interview. For the purposes of comparison of experiences, it will be assumed that there were no drastic changes in school
demographics between the time periods discussed by the participants. Two of the coaches also discussed their experiences as students. Both returned to coach at the schools where they had competed. No demographics are provided in the table for those schools during the time the coaches were students there.

## Cross-Case Analysis

## Introduction

There are only a handful of studies on the Science Olympiad and no studies investigating the experience of middle (Division B) and high (Division C) school coaches. This study explores the opinions and attitudes of twelve Division B and Division C coaches with a goal of shedding some insight on what about Science Olympiad is appealing to these coaches.

This is a hermeneutic phenomenological study in that it seeks to explore the many ways that coaches experience Science Olympiad. To accomplish this an open-ended questionnaire (Phase I) was administered to coaches in person at three SO tournaments or via email. Returned questionnaires were used to develop questions for a semi-structured interview. These questionnaires were also used to identify candidates for participation in the interview portion (Phase II) of the study. Twelve coaches participated in the interviews.

The first part of this chapter includes a summary of the data from each of the twelve individual cases The second part of the chapter presents key findings and conclusions with the third section relating some of the key findings to the literature. The chapter ends with a summary of the advice coaches gave to help other coaches.

Table 4.1. Subject Profile Overview Data and Information about Schools Served

| Subject | Science <br> Olympiad <br> Category | Years of Experience* | Campus Grade Levels | Campus Enrollment** | Location*** |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Anne |  | Anne (17 Total) |  |  |  |
| Student | C | 3 | 2 yrs -12 | -- | City $\ddagger$ |
| Coach | C | 14 | 2 yrs -12 | $1200 \ddagger$ | City $\ddagger$ |
| Barbara | C | 12 | 7-12 | $69 \dagger \dagger$ | Rural-Remote |
| Beth | B | 12 | 6-8 | 623 | Suburb-Large |
| Kelly |  | (18 Total) |  |  |  |
| $1^{\text {st }}$ school | B\&C | 2 | PK-12 | Private school, closed $\ddagger$ | No data $\ddagger$ |
| $2^{\text {nd }}$ school | B\&C | 8 | PK-12 | Private school, closed $\ddagger$ | No datat |
| $3^{\text {rd }}$ school | B\&C | 8 | PK-12 | $1292 \dagger \dagger \dagger$ | City-Large |
| Laura | B | 15 | PK-8 | $186 \dagger$ | City-Large |
| Leslie | C | 2 | 9-12 | 345 | Rural-Distant |
| Mark | B \& C | 5 | 6-8 \& 9-12 | 530 \& 637 | Town-Fringe |
| Matt | C | 3 | 9-12 | $3485 \dagger \dagger$ | Suburb-Large |
| Robert | C | 4 | PK-12 | 952 | Suburb-Large |
| Sandra (16 Total) |  |  |  |  |  |
| Student | B \& C | 6 |  | -- |  |
| $1^{\text {st }}$ school | B | 2 | 6-8 | $653 \dagger \dagger$ | Rural-Fringe |
| $2^{\text {nd }}$ school | C | 2 | 9-12 | 878 | City-Large |
| State Director |  | 6 |  | -- |  |
| Scott (19 total) |  |  |  |  |  |
| $1^{\text {st }}$ school | C | 2 | 9-12 | 110 | Rural-Distant |
| $2^{\text {nd }}$ school | B \& C | 17 | 6-8 \& 9-12 | 826 \& 941 | Town-Distant |
| Sophia | C | 15 | Homeschool | N/A | Suburb-Large\% |
| *Years of Experience: years involved with Science Olympiad as either student, volunteer, or coach including the current school year at the time of the interview. <br> **Enrollment: the total number of students in attendance during the 2019-2020 school year unless otherwise noted. <br> ***Location: the locale classification of the school district according to the National Center for Education Statistics <br> $\dagger$ Enrollment information based on 2017-2018 school information as the most current <br> available from the National Center for Education Statistics at time of interview. <br> $\dagger \dagger$ Enrollment information based on 2020-2021 school information. <br> $\dagger \dagger$ Enrollment information based on 2021-2022 school information. <br> $\ddagger$ No NCES report available for these private schools. Information from websites or given by interviewee. <br> Enrollment, Campus Grade Levels, and Location data were obtained from the National Center for Education <br> Statistics https://nces.ed.gov/globallocator/sch_info_popup.asp |  |  |  |  |  |

## Results Related to Research Question 1 Sub-Question 1A

RQ1: According to coaches, what knowledge, skills, and personal growth opportunities does Science Olympiad provide?

SQ 1A: What experiences in these regards do coaches see students having?
Themes that emerged from the data are listed in Figure 4.1 and discussed individually in the following sections.

Figure 4.1: Themes Related to Research Question 1 Sub-question 1A

| Students increase in content knowledge with Science Olympiad participation |
| ---: |
| Increased awareness of STEM fields and career choice |
| SO helps in building personal skills |
| SO offers opportunities for leadership and teamwork |
| Competition makes the science activity fun for students |

## Students increase in content knowledge with Science Olympiad participation.

The most common comment made by coaches about the benefits of Science Olympiad (SO) is how Science Olympiad participation resulted in students having increased content knowledge which they demonstrated in a classroom setting or testing situation.

In Appendix H, Barbara, who is the sole science teacher for grades 7-12 at her school, reported that students who competed in Solar System or Astronomy always scored better on that in her class. This is a clear indication that knowledge gained in the SO, perhaps even without the student realizing it, is connected to classwork. She gave the example of a student, "In class we got to talking about waves and he knew all kinds of stuff that I don't think he really realized he knew." Beth (Appendix I) is a community volunteer coach and does not see their classroom
performance, but she hears comments from them and has followed the careers of former team members through college. She comments that the knowledge gained through Science Olympiad is more in depth and at an earlier level than they would typically be exposed to it which can have a later payoff. "If they started doing Anatomy \& Physiology events in 6 th grade and go all the way up, when they hit AP Biology or take A\&P in high school, they may not know all the answers, but they have the vocabulary." Beth adds that if they really want to do well in a Science Olympiad event they must go deeper. "You might talk about birds in Biology, but in ornithology they're learning all the differences between the types of birds and even the calls, which you aren't going to get that in a biology class."

Mark (Appendix M), a robotics coach who added SO coaching about 5 years ago, supports Beth's comments that Science Olympiad provides students a time outside of class for further content knowledge development. He likes it when students show interest beyond the presented material. However, he usually does not feel that he can give them the time to go explore during regular class time because classroom time is limited. "So, you kind of quell the ancillary questions on it, you know." He also cites the Ornithology event or giving students an opportunity to learn about a specific class of animals beyond anything they would learn in a high school class. Additionally, he mentions that students are working with CRSPR in Chemistry and learning programming in the Detective Building module.

Robert, who is a retired engineer turned teacher, mentions the depth of knowledge that students must develop to prepare themselves for competition. In Appendix O, he gives the example of Biology. He says there is a "very shallow, but broad scope of topics that you cover in a biology class." He compares that to some of the biology events. An example from one event is that students had to look at a particular type of pollution accumulating in a specific
waterway that was affecting an amphibian. Robert sees this as more associated with the real world than what is frequently covered in the classroom. He points out that the reason the classroom must be more generic in coverage is because it must provide a broad base for students who will go into diverse specialties. "I don't think there is a school that could afford to have a class on every one of the different science events that we participate in." Kelly (Appendix J) who has built SO programs at three different schools, has a similar opinion to Robert through her statement, "It exposes them to topics we wouldn't be able to cover in school."

Science Olympiad participation impacts content knowledge for homeschoolers according to Sophia (Appendix R). She thinks this is especially true for middle school because the focus of available guidelines is not as much on college prep yet. Satisfying college entry requirements comes later so a great deal of middle school curriculum is very open and up the parents' discretion. Sophia states that Science Olympiad can provide some structure for what they are going to study. For example, if the student is going to compete in Food Science, then their science that year will be everything involved with the Food Science topic for that year. The topic for the 2021-2022 competition year was candy making. Sophia says, "There's a lot of different things you can do related to that."

For students who have already decided on a STEM career, Mark and Beth both discuss how Science Olympiad can help students get a deeper knowledge of their chosen field beyond what can be offered in a regular classroom. Beth talks about how she struggled in college because she did not have the opportunity to learn some field specific knowledge due to her small school not offering advanced classes. She sees her Science Olympiad students acquiring that type of knowledge and skills through Science Olympiad events.

Laura, who is a social studies teacher and has taken a middle school team to the national competition four times, reported in Appendix K that students learn more than science content. "I've noticed that when we would do our state history or I would do geography with them and we do latitudes and longitudes, those kids that had done Road Scholar would help the other ones find the latitudes and longitudes." She says that Road Scholar also teaches students about polar extremes and how to use coordinates. She says that over the years different things from `have related to various things in her history class. Laura says that elementary and middle school are each in their own little worlds. "I mean, think about it. Middle school blames primary teachers for not teaching certain things. High school blames middle school for not teaching." She adds that college blames everybody, but she agrees it is true. She says that her $6^{\text {th }}$ graders do not know the states and capitals or the presidents. She taught both of those when she was teaching $5^{\text {th }}$ grade. "They don't teach them anymore."

On the issue of state test scores both Scott and Laura claim a positive impact. Scott (Appendix Q) says, "The hours they put in preparing notes for Science Olympiad helps them become more efficient, studious students for school for their everyday classes. And the test scores, they show that, I think, across the board they reflect that." Laura states, "When we started doing Science Olympiad, our science scores started shooting to the top. We went to Excellent rating in State where we hadn't been before." She says that even the students who eventually say it is too hard and give up on the competition still learn some science in the process. "That is why we don't limit who can be on the teams."

Others seemed more hesitant to claim a correlation between SO participation and high test scores. Beth says that her school has always had higher math and science scores than the other high schools in her area which has just recently started a Science Olympiad team.

However, she is not sure that Science Olympiad can be credited with all the differences. She thinks it also has to do with family and environment. The families at her high school are interested in science and STEM and push their kids in those areas. She says that is why they have had Science Olympiad at her school over the past decade. So, Science Olympiad may be helping boost the scores or the scores may be high due to the community emphasis on STEM and the Science Olympiad team is a byproduct of that interest.

Kelly (Appendix J) feels that many of her Science Olympiad students are top academic performers anyway, so it is hard to say if Science Olympiad influences their in-class achievements or not. However, for students with learning differences she thinks there is a score increase just because of self-confidence within themselves gained from taking tests in Science Olympiad competitions. Anne in Appendix G and Robert in Appendix O express similar views to Kelly that their Science Olympiad students are the top students so their scores and classroom performance will be high anyway.

## Greater awareness of STEM and career choice.

Another benefit of Science Olympiad participation reported by coaches is that students get to experience different STEM topics and find an area they like. Coaches say that sometimes they see a student find their passion and it can be life changing for the student. Scott comments that many students he sees join Science Olympiad are already considering a science vocation, but they may not know which specific field they are going to pursue in college. Science Olympiad can help them identify that specific field.

Anne thinks in Appendix G that Science Olympiad exposes students to science topics beyond what they would get in school course offerings and in other competitions like robotics which are limited to one or several very closely related fields. She says, "If a student is interested in biology or in medicine, you need somewhere else for them to kind of explore that
knowledge." With Science Olympiad she says that it does not matter what age they join, whether they have done Science Olympiad before, how many science classes they have had, or anything about their personal background. "If they are interested, I can plug them in with something and I think that is really great."

Robert (Appendix O) explains how Science Olympiad pushes students beyond the four main high school sciences. "It's a huge spectrum of exposure to science that obviously when you take biology, chemistry, physics and then maybe anatomy in a curriculum, well that's four topics." Science Olympiad offers twenty-three events each year. Many of the events change or rotate on a regular basis so that a student who is in all four years of high school has more than twenty-three options to explore over the course of that time. "There's a lot more just introduction if nothing else to, uh, to these different fields and concepts."

Sandra (Appendix P), a former student participant, coach and now a state director, echoes Robert in pointing out that most schools only offer the basic biology, chemistry, and physics classes. "There's so much more out there that students could be aware of and so Science Olympiad kind of helps out with that by going a little deeper into the content areas and perhaps touching on some topics that the students would not have learned in their basic science classes at school."

Beth (Appendix I) thinks this is what Science Olympiad does best. It introduces so many different concepts to students that they may not get elsewhere. "They can choose out of so many different events that cover so many different areas of science; but then once they choose that event, then they tend deeper into that than they do in the classroom." Depending on the size of school, many of those topics the students are going deeper into might never be in the classroom to start. Some small high schools only offer physical science and biology classes in their
curriculum. "Kids that don't take Physics may get exposed to those concepts in builds. Kids that don't take advanced Biology or Chemistry will learn a lot in those events. Just hearing the ideas and the concepts being discussed is important."

Laura sees Science Olympiad being of particular benefit to her students in Appendix K because of the way her small private school functions. Every teacher teaches two subjects. The teacher who started the Science Olympiad team was a Religion teacher and that was all she taught until everyone had to start picking up a second subject. Then she wound up teaching science. Laura says that the school has rarely had a person who was qualified in science. The school is set up to where one teacher teaches social studies and literature, another teacher does religion and English, and a third teacher handles math and science. "That's the way our school is," says Laura. She says that typically the person teaching science is actually a math teacher and it is often not a good match. 'I mean, it's interesting. The math teachers don't want to teach science." Therefore, the opportunity for the students to learn science outside of school with mentors that spend time explaining topics to them is a great benefit to the student.

Kelly (Appendix J) believes that students grow intellectually. Sometimes for a tournament she will have a category or two not covered by the team. There will be students who want to be on the team and Kelly will ask them to try one of these categories even though they do not know anything about it. She says that often they find they love it. They will come back to her saying, "Wow! I never knew anything about this!" Leslie relates a similar common experience where a partner is not able to come to a tournament and the remaining partner does not want to go in alone. She will ask one of the other team members to give it a try. She says that sometimes the student will come back from the event saying, "That's awesome. I'll do it again." Other students find that it is not their "cup of tea".

Beyond exposure to the variety of STEM topics and potential careers, Science Olympiad can enhance a student's perspective on those fields. Kelly says that students often think that science is confined to a classroom. "This kind of expands their experience with science and for some it really creates a love for science that they would not have had." She gives the example of her daughter who loves the building events. "She would not have gotten that in her class at all and so she realizes that there's more to science than just academic books and paper and maybe a lab, you know, kind of thing."

Sophia sees the in-depth focus into particular topic areas helping students create career interests. In Appendix R she says, "A lot of the high school students take classes at the community college and a lot of them have chosen classes based on what they've done for Science Olympiad." Because some of her students have done well in the Anatomy and Physiology event, they chose to take that class in college and are now studying to go to medical school. She says there is a student who probably would not have considered meteorology for a profession before competing in that event and is now in school to become a meteorologist. She also has had students discover new areas of interest through Science Olympiad. Sometimes students do not get to compete in an event they want due to schedule conflicts putting two of their events at the same time. Often in these cases coaches ask students to enter a different event so that the team does not have to take the penalty for not entering that event. Sophia says, "We have a lot of kids that discover that, you know, when they step into another event because it's not filled, they find things that they really like."

As a former participant, Anne says in Appendix G that Science Olympiad prepared her and her teammates for a lot of things in life and career and it especially taught them to work with different people. Though not all her friend group went into a science field, most of them
completed doctorates in their chosen field. Likewise, she has seen some of her students continue into science fields. "If you find you are good at something within science, you find that there are a lot of other different pieces of science you also might be good at." She says she has had a lot of students go into engineering fields. More often, though, she says that Science Olympiad just offers topic exposure and it is fun to see them fall in love with a science topic even if they do not choose to peruse it as a career.

Barbara has had students go into biology, chemistry, and biomedical fields. In Appendix H she is hesitant to say that their choices were due to Science Olympiad because the students were likely already interested in those area beforehand. However, she thinks it might be possible that their participation in those events lead the students to consider those areas for careers instead of just a passing interest.

Mark (Appendix M) encourages the students to approach Science Olympiad with a potential career goal in mind. He asks them, "What do you want to be able to do? What do you want to know?" He says some of them come in with a focus on medaling, but he prefers them to keep the goal of their education and future in mind more than winning. "This last group of kids were more focused on the win, but they knew - they knew their end goal, you know. Get a scholarship and go to college and they matured nicely."

In Appendix N, Matt says "I've had students who have gone into the medical field very likely because of Science Olympiad." He cites the Protein Modeling event for sparking their interest. However, Matt also gives an example of the opposite happening where a student lost interest in an area. One student was planning to go into the medical field, but because of the Sounds of Music event they decided to continue with their interest in music and the science
behind it for a career instead of medicine. "So, definitely Science Olympiad can be the vehicle to lead a student to a pathway or a career where they can find real enrichment . . ."

Having only been a coach for five years, Robert says in Appendix O that he does not have enough data to state whether Science Olympiad participation affects career choice. He thinks it is likely that Science Olympiad participation sparked interest in some students for areas and because they enjoyed it, they pursued it in college. He knows of one student that excelled in some of the build projects that is now majoring in engineering. "I don't know that this necessarily was the only reason why he chose that as a major because he had a natural talent that was just unbelievable, but it probably helped reinforce his enjoyment in pursuing that type of STEM career."

The first thing that is most obvious about Scott in Appendix Q is his enthusiasm for Science Olympiad and the opportunities it offers students. In his nineteen years of coaching, he has seen involvement in Science Olympiad change students and set them on career paths in STEM related fields. He says, "I'm still in contact with every single one of my very first group of kids from middle school. Some are finishing up their PhD's. Some have their PhD's. They're professional." Scott estimates that 40 to 50 percent of the students that have competed on his regional and state teams have gone on into science fields. For the students that do not make those teams but stay involved with Science Olympiad on the invitational teams, he thinks about 25-35 percent have continued into science fields. "I think a lot of that is the kids I get in Science Olympiad already have that vocation of moving on to science in their college career." As part of an effort to have students expand their topic knowledge, Scott asks students to compete in multiple events. He likes to let the students choose the events they want to compete in, but he says he always must challenge some students to consider some of the unpopular events
so that the team has them covered. He tells them, "The more versatile you make yourself to us, the more valuable you are to us." He tells them that it is a great goal to want to win state in one event, but the team needs members that can be competitive in multiple events.

Anne and Sandra are both former student participants in Science Olympiad and are examples of how participating in Science Olympiad can encourage a student into a science field. Sandra began participation in middle school and continued throughout high school while Anne began participation in high school.

## Science Olympiad helps in building personal skills.

## SO helps students learn time management.

Time is one of the greatest challenges for both students and coaches. Scott says in Appendix Q that time is the major cost for student participation. "The vast majority of the time for those that are successful is spent outside of our time together," explains Scott. "Especially at the high school level since we meet so rarely. At critical points coming up to meets we will make ourselves available, but most of the time to do this is done outside of school." However, coaches see it as one of the greatest benefits for students who overcome the challenge and learn the skill of time management. It teaches students the importance of planning their time and forces them to devise personal means of being efficient with their time. "But we have to fight with - our kids do everything," says Laura (Appendix K). "I mean, there's a chess club and there's - there's a scholar bowl thing for the diocese, there's a religion bowl with the diocese, there's sports." Because they are a small school, Laura tries to share her students with the other activities and hopes they share in return. "We have to schedule all around all of those things and the smarter kids are in all of those, you know." She says it comes down to if Science Olympiad is what they want to do then something has got to give because the other organizations want the students' time just as much. "And so sometimes it's like choose. What do you want?" She
continues, "But we do work with them. I mean, you know, especially around sports. We work with them. Make sure that they, you know, can do sports, and can do this." Anne (Appendix G) is at a larger school but says that it is challenging for her students to set up practice times to fit their schedules. Most coaches in this study do not have a class period for Science Olympiad, so meetings are outside of school time. "It's just one more thing in their lives that they're scheduled for, and our kids are really over scheduled," says Anne.

Robert in Appendix O is at a private school with the same religious affiliation as Anne's private school. He explains how his students also have a lot on their schedules. He says that sometimes students will be fully active in the fall, but then the winter or spring sports start. "We lost one of our best team members because he - every weekend that we were trying to do workdays - he was away on a soccer tournament." The student made the comment, "I can only do one." Robert says he lost another student who was one of his best biological event competitors when the student was selected for state honors orchestra. Baseball season took one of his best "build" students and one of the Science Olympiad coaches who was also a baseball coach. "Poof, suddenly we don't get them on weekends because they're always gone to tournaments and games." While some schools just accept that students involved in sports are not going to be Science Olympiad participants, Robert's school requires all underclassmen to participate in a sport or physical fitness activity. "Unfortunately, a lot of times when students have to pick between a sport and Science Olympiad, even though these are the smartest and best kids around, they're picking the sport."

Barbara (Appendix $H$ ) reports a similar difficulty even though she is at a small rural school. She says that if there is a conflict with a sport activity, the sport will always win over Science Olympiad. However, it is not always school activities that cause problems. "Sometimes
it was the parents that didn't understand that Science Olympiad was just like everything else." She says she always sends a signature sheet with the parents so they will know the dates of the tournaments, but inevitably they plan other things anyway. She does not think they would do that if it were a sporting event. She feels that after a student has spent all that time practicing, they deserve for the parents to make sure they can attend the competitions.

In addition to the sports conflict, Robert describes how his students are also academically overloaded. Robert says there is a lot of diversity in interest and activities in his team members. "When you talk about a profile of the students that are actually participating, a lot of them are highly motivated kids that are taking AP classes and things like that and, quite honestly, a lot of them are taking a full load." Robert explains that the typical student that expresses interest in the fall is one that is taking seven classes (five is considered a full load), a sport, and a performing arts class. He can lose half of those interested students before Christmas. "[It] is the reality hit of getting into the school year and finding that when you take three AP classes, it really does suck up all your free time." So, students who competed all through middle school and would be great contributors to the team get overwhelmed by the academic load and realize they cannot afford to spend a weekend doing Science Olympiad when they need to study for three exams on Monday. "There are so many more distractions in the upper division that it's hard to maintain a full commitment to the Science Olympiad."

Kelly (Appendix J) also says that her program is competing with all the other programs for the student's time. Students have other school functions as well as things with friends that they sometimes decide they would rather do. Kelly agrees with what Barbara says earlier about the impact of parent support. If the parents are prioritizing other activities, then the student will choose the other activities, but if the parents are supporting the student's participation in Science

Olympiad it makes a difference. "It helps there when you have that parent support that they just keep the kids committed when they're being pulled between different departments." Robert also experiences issues with parents prioritizing other things over Science Olympiad and not just the practices, but sometimes the competitions as well. He gives the example of a student saying, "Oh, my god, I did not know my parents are taking me out of school for a week to go do college visits. I won't be here for that tournament."

Sophia says in Appendix R that one of her biggest problems as a coach has been with parents not always agreeing on how the team should be managed. Also, she says, "Not all gave students the support they required (i.e., help scheduling meeting with partners, getting materials, rides to see partners)." Another challenge she names is with students who are not interested in being on the team but who are pushed to participate by their parents.

Sophia also sees the high school division students having time challenges due to their academic load. Especially, those who are attending community college must balance schoolwork and exams with competitions. "The high school kids are all juggling college schedules because they almost universally are taking probably close to 12 credit hours at the community college." She says that this makes it hard for the juniors and seniors to find time for Science Olympiad. However, she thinks this is probably comparable to regular school students with AP classes.

Matt also talks in Appendix N about how involved his students are in other things.
"They're usually in high level academic classes which requires time outside of class to read and study and all that kind of stuff." He says that they may want to spend hours and hours building or studying for their event, but they have so many other priorities. They are also active in other school activities. He uses his treasurer as an example of a student who is also an officer in
another school club. He sees the drawback being more than just the students not being able to spend the time they want to on Science Olympiad. "They might feel like they're letting the team down if they're not all in all the time spending hours and hours." He says they are really pushed and pulled in every direction.

Leslie (Appendix L) attributes the attrition of upperclassmen to several factors. As stated by Mark in Appendix M, students get jobs. She mentions other school activities such as sports, but at her school FFA is popular. She explains that the students involved in that have a show season in the fall and speech competitions in the spring, so she loses students to conflicts there.

Most of the coaches interviewed for this study expressed the view that a dedicated class time for Science Olympiad during the school day would alleviate some of this conflict. Only one of the coaches (Kelly) in this study had a class hour, though several believed that rival coaches did have a dedicated class and that was why they won so much. Two of those rival coaches mentioned by others (Anne and Robert) were in this study and typically win or take second in their respective state tournaments each year. So, the belief that other schools outside this study have dedicated classes may be equally unfounded. Several coaches mentioned that their school allowed a little time during the day at least once a week where clubs could meet. Beth's school (Appendix I) is one of those that allows the team to meet during the seminar time on Friday. This helps reduce some of the out-of-school time pressure on the students, but Beth explains it is not a large amount of time. "They squeeze it between like second and third hour on Friday and I don't get it every Friday because that's what they use to do like assemblies." She says she will also lose her juniors sometimes for ACT prep and the seniors will get pulled out for graduation related things. "I usually don't have the whole team at any given seminar, but it's enough that we can coordinate and then they can go out and talk to their event buddies."

Anne points out that Science Olympiad takes more time than some of the noncompetitive or what she considers "social" clubs because of the frequency of teammate interaction. A club like the French Club might meet once or twice a year to do an activity, but with Science Olympiad the interaction is constant. "The kids are talking to each other. They're preparing and having conversations all the time." She wants to consider this a benefit, but the fact remains that Science Olympiad takes more time than some of the other clubs. There is a stronger analogy to a sports team with the number of hours of after-school practice required in order to be competitive. This time spent together, though, is where coaches see the camaraderie and team spirit start to develop.

With difficulties in even scheduling time to practice follows the question of how much practice time is needed each week. Coaches agree that event preparation takes a lot of time. The amount of time commitment relates to the goals of the team. "It depends on the school," says Sandra (Appendix P). From the observations of the schools in her state, she thinks that the prep time depends on the students' personal tendency to study and the arrangement at the school. "If you have a school where you have limited coaches and the team meets together once or twice a week, then they're probably meeting one or two hours a week." However, she says that if the team is lucky enough to have multiple coaches doing the events, then it can vary. This was the case when she was competing. "When I was a student in Science Olympiad, we had practices every day after school for an hour to an hour and a half." She explains that there are also schools where Science Olympiad events are tied into their science curriculum. "Like they might actually have an elective class that's dedicated to Science Olympiad. So, then those students are doing Science Olympiad during the day in their class. So, it really depends on the school and how they handle it." It varies by student too. Some students will only practice when the team is having
practice and then some kids prefer practicing on their own so they may go home and study for several hours on their own.

Beth (Appendix I) knows other coaches whose goals are to win and move on to the next level of competition, but she thinks that should be the team's decision. She tells them, "You know, if we actually made it to nationals that would be a miracle, but, you know, if you guys really want to fight for it, that's fine with me." She says that she knows how much time the students have available, and she does not think it is realistic. "If they want to go to Nationals," says Laura," they're going to eat and sleep and breathe that almost." She gives an example, "If you've got seven of them that are in most of the events, you know, each of them is in like four events. You've got the events covered with somebody and they're studying those." She expects them to spend an hour per event studying or working at the meeting and then she expects them to take that times four at home during the week. That is a huge time commitment. "I mean, if my kids only spent their extra time on Science Olympiad, we'd be going to Nationals because they have everything they need to get to Nationals through our coaches."

As mentioned previously, Beth's school allows the team to meet during the seminar time on Friday. This helps reduce some of the out-of-school time pressure on the students, but Beth explains it is not a large amount of time. "If they only had Science Olympiad to do, we'd be going to Nationals frequently," Laura comments referring to her earlier statement about having to fight for the student's time. "You go to those Eastern schools or even, you know, like Troy High School out in California. That's their one thing so everything is based around that. Ours isn't." Laura thinks that the founders of the Science Olympiad 35 years ago did not expect it to become what it is today. She asks herself if the "motley little groups" here in the Midwest can ever beat the bigger teams further East at nationals. She does not think so. She says there is a
whole different feeling on the east coast about jobs and work ethics compared to her location. "We're so much easy going, you know, and they're - they're like dog-eat-dog." She says that you do not realize it unless you have lived it or seen it. So, for her it is not about the prospect of having a team that can win or place at nationals. "I think it's a great way to get kids involved in every part of science so that's, you know, that's why I do it."

Even with a small team Leslie (Appendix I) has difficulty getting students to commit to regular practice. "Trying to find a time to meet with them gets less and less." The students have a class time in middle school for Science Olympiad and without the class time in high school, she sees them drift away. "It's kind of frustrating because we don't have an hour during the day and by the time they get to be Sophomores really, they're hooked up in about a thousand other activities." She says that typically she has only one to two juniors or seniors on the team. She thinks that one of the causes of this is that they get jobs so they can have cars and things. To still get practice in during the school day, Leslie says that some students will try to work in a few minutes at the end of class times. She says that most of her students put in the one hour a week after school and not a lot more. She says the ones that are taking it seriously and are all about the win probably invest a lot more time than that. The first year she did Science Olympiad, she held practices before school. "Getting high school kids up early doesn't always work out real[ly] good either." So, she changed to the one hour after school one day a week and if the students need more time, she will stay later with them.

Mark in (Appendix M) says his students come into Science Olympiad aware of the time required because, as previously mentioned, they competed for him in TSA competitions in middle school. He says you also must know the individual personalities of your students. Some
of them work over a period of time and others are great at procrastinating and getting it all done at that last minute. Therefore, it is important to help them find the right partner.

Matt says in Appendix N that his team meets twice a week on average. "It's after school two days a week and then on a Saturday and sometimes on Friday if they haven't finished building their stuff." Some of the events require students to build models or machines before the competition and these can require a large amount of time from both the student and the mentor.

Robert says that there is not enough time during the day for Science Olympiad preparation. Like Beth, Robert also has the once-a-week club meeting time at his school. During school time there are 20-30 minutes a week allocated to club time. He says that really is not long enough to accomplish anything for Science Olympiad especially if they are spending part of it walking to the middle school to use the maker space. He explains that the school has a large campus and students must walk around a lake to get to the middle school. When they get there, they often are interrupting another class to borrow a little bit of table space and borrow some tools. He does not feel it is an efficient use of time and is trying to get a space at the high school for the students to work and store their equipment.

As previously discussed, many of Robert's students are also involved in other clubs all trying to find meeting times. After school are the required sports practices, so that conflicts with several students. That basically leaves Saturday as the only time the team can get together to work on things. Of course, the tournaments are also on Saturdays. Some of the other clubs also have Saturday competitions and soccer is mostly on Saturday. Just like the coaches are sacrificing personal and family time to meet or compete on Saturdays or holidays, the students and their families are also faced with the choice of sacrificing family time or another activity for Science Olympiad. He says that it presents a challenge to the students to not have class time
during the school week that they can use to fulfill their Science Olympiad activities. The team sometimes does practices for two or three Saturdays in a row prior to attending an invitational. This cuts into family time for both the students and the coaches. "It really adds up quite a bit." He says they had times over the Christmas holidays they tried to have workdays. He says some of the parents told him, "Well, this is Christmas holiday. We're traveling and, no, we won't be back for you to spend an extra day at Science Olympiad."

Coaches have differing opinions on which type of event requires the most prep time and how much time students should invest. Mark says in Appendix M that every event is different in how much time it requires. "Some of the builds are incredible. Like the Flight one. That is incredible. The one - Detector Building - way incredible amount of time for the kids to spend on that." He believes that the build events take more time. Builds are obvious in the number of trials that a model must go through in order to be tweaked to its ultimate performance ability. However, the testing events require the amassing of notes in an organized fashion. Most testing events allow the students to bring some notes into the test. Some may allow an entire file folder while others allow only a page. Both scenarios require the student to determine which material should be included and to organize it in a fashion that can be easily utilized for reference during a timed test.

With the knowledge events Mark says that he can just give the students tests periodically and see how they do and then talk about it and decide what additional information the students need to research. The building events require building and testing followed by rebuilding and retesting and that process can continue up until the event. Test files are important for the testing events. To begin with five years ago, they did not have an archive of old tests for the students to study, but now they have about five years' worth. "When we get done with a competition, I'll
scan them all in and put them on our Google drive so that we can have those." He says that any new student on the team can come in and access that. "It's probably a little bit more overwhelming for a new kid to come in and say, 'I can't learn all that'." So, he says that you leave it up to the students on how they want to utilize the archives.

Laura (Appendix K) has her team practices structured in such a way that there is not much difference between time spent on building events and testing events. As previously mentioned, her students spend an hour a week with their mentor for either type of event and then are expected to spend an hour per event working on it at home each week. She says, "If they want to go to Nationals, they're going to eat and sleep and breathe that almost."

Leslie (Appendix L) thinks that students invest a lot more time in the build events than in studying for the tests. Leslie thinks the build events require more time than the testing events but would like to see her students put more time into all events. "I think if they were taking it serious and they were all about the win, they would probably invest a lot more time in the testing events."

Sandra in Appendix P suspects that the builds take more time. "Because they have to build the device, test it, which usually means breaking it, and then rebuild it, test it, break it, rebuild it and so I would naturally assume that takes more time." However, students who are studying for written tests may be putting in as much time, but it is not as visible. As mentioned before in student benefits, there are some students who will have the one written test event topic that is their love. In Sandra's experience these are usually identification events. She explains that ornithology, insects, and invasive species each stay for two years and then rotate. "So, you'll have some students that just love those ones and they will study nonstop." She has even known students to join the professional organizations that study those particular topics and attend
meetings of that organization. "Obviously, these students have put in a lot of time to learning that event and you can usually tell which students these are because if they don't take first place they're absolutely crushed."

Barbara (Appendix H) says that less experienced students may need more prep time. "It's hard to get them to realize what they need on those notes." She sees the middle school students requiring more coaching because of their inexperience. She says they do not know what they need to do or how to manage their own time well. Scott supports Barbara's observation. He typically sees the middle school students copy and paste a bunch of stuff and then after the $1^{\text {st }}$ tournament realize that they are not good. "We'll help them parse that out to a more reasonable level." Overall, he says that middle school students will probably have their notes for regionals done in a couple of weeks, but to do it right takes more time than that. "To get your notes right, it takes multiple meets and multiple weeks to get the notes fine-tuned to the information that you think is important."

In Scott's opinion (Appendix Q) build events do not take more time than testing events, "If you really want to do your best and end up winning state, then the test events can take a little bit more time," he says. "The thing about the build events is you have to build multiple copies and you test it and you analyze where it broke. And that takes multiple tests and running multiple graphs in Excel and analyzing small changes." However, he explains that the student who spends the time to properly developing their notes for the testing events can spend as much time or more than they do on the building event. Scott says that for the high school students "it will take them dozens and dozens of hours to develop the notes that they can take in and finetune them." He points out that the building events use up materials and so the time and effort is more visible.

As far as the hours involved, Scott says, "Well, if we meet at the middle school twice a week, that's an hour right there and, if you're doing a tester build (this is a term for a prototype to test how a design or materials will perform under competition conditions), we ask that they spend at least twice that amount outside to do well." He says it usually takes them not doing so well at the first meet to realize "Wow! I need to put in more time." He estimates that from September to November or December when the first meet occurs, the kids are putting in about two to ten hours a week. "And it usually takes them getting their tails kicked at their first meet to realize they need to put in more time." After the first meet, the kids that are serious and dedicated understand what it takes and will increase their preparation time from 10 to 20 hours a week. "They may have a build party at one of the person's houses on Saturday and spend eight hours working on their mousetrap vehicle or their bridge and then they might not touch it until the following weekend." Most students are competing in multiple events, so his statement implies that during the week they are spending time studying for their non-build events.

Beth in Appendix I has found a way to involve students who want to be on the team but cannot make it work in their schedules. She says, "I even have supporters." These are students who would like to be on the team but cannot commit to the time. "They just come to seminar and have snacks and talk to the other kids," she says laughing. "But, you know, they generally are pretty interested, and they help me when I have regionals. They'll be people that show the kids to where the rooms are. They sit in the front, you know, and do registration for me." She explains that these are sometimes her juniors or seniors that were previously on the team but had to leave due to time conflicts. "They don't - a lot of them just don't have time to give to an event, but I figure, you know, they're in the room. They hear the science stuff. It's all good."

## SO helps students learn to prioritize, organize, and work efficiently.

Balancing all the things requiring time in their lives means that students learn how to prioritize and to work as efficiently as possible. Some of the coaches mention that students learn to retain their folders from year to year, so that as time goes on, they only have to revise the information instead of completely starting over each year. Beth uses her son as an example. He was in Disease Detectives from the time he was in sixth grade all the way through his senior year. She points out that if they have been doing similar events since $6^{\text {th }}$ grade, they can have some good note pages and not have to spend a lot of study time their senior year but still compete well.

Scott (Appendix Q) says he sees the students develop self-awareness and efficiency. "You have to be efficient or you're not going to do well." He tells the students that they cannot expect to build something the night before and have it do well in competition. Beth says she tries to downplay the focus on winning. She says that when they are setting goals at the beginning, she explains to them what it will take to win state and go to nationals. "If you really want us to go out there and, you know, win state and go to nationals, that means you're gonna have to prioritize Science Olympiad first." She says, "They all kind of think about it for a few minutes and say 'OK, no' and then we move on." She laughs about this.

Anne in Appendix G thinks Science Olympiad might cause some students to improve their organizational skills, but she sees most students bringing those skills to the table to start. However, it does give them an opportunity to practice those skills. She likes to encourage the social aspect and before Covid the students did a variety of things. "We have the kids plan parties and get-togethers and usually after the meetings they play soccer outside in the field." The high school team also elects officers and mostly runs their own team. "It's a chance for
them to get experience working on committees and negotiating with each other and organizing things like that."

## SO fosters student growth in confidence and willingness to challenge themselves.

Where Anne sees Science Olympiad impacting the students the most academically is the building of confidence and developing a willingness to challenge themselves. "A lot of it is they just feel empowered to take harder [more advanced] classes." She uses herself as an example. ". . . I wouldn't have taken physics in high school if I hadn't done Science Olympiad. I was scared to death of that. Now I teach physics." She sees some of her Science Olympiad students doubling in science classes in their junior or senior year because Science Olympiad has given them the confidence to know they can do it.

Kelly (Appendix J) sees confidence as a major benefit for students. She credits the number of categories of events for offering a wide range of opportunities. "There is just something for all of them and their confidence just grows within themselves." She sees this as especially beneficial for students with learning difficulties. An example she gives is her daughter who has trouble taking written tests but thrives in the building aspects. "[She] very much pays attention to details and it makes her feel so much more confident. Especially when she wins those categories."

## SO assists students in gaining research skills while learning to curate resources.

Research skills, note taking skills, and learning to curate resources all lead to improved test taking abilities. Preparing for a testing event requires the student to do research of their topic on their own. Sophia states that this is an important skill for students to become self-sufficient in learning how to study as preparation for college. Anne explains the process for Science Olympiad. Students compile their research for the tests into a binder. The information is then condensed into "cheat sheets" depending on the rules for each event. These are sheets that
students are allowed to bring into some of the testing events. Scott explains that the rules are available free online, so his high school kids will often access them as soon as they are released in the summer and come to school with the rules in hand. He says, "From that, they start developing the notes that they can take in. Some events like Astronomy or some of the ID events, you're allowed a three-ring binder that you can fill to your heart's content." In referring to ID events, Scott means any event where identification of species, objects, or parts of something occurs. Two examples of these types of events are Anatomy \& Physiology where students may be identifying bones or muscles and Ornithology where students may be identifying bird species by appearance or by their call. Other events are a little more restricted as he gives an example, "In Meteorology, you're allowed one single sheet of notes to take in front and back."

Laura and Scott both discuss how this process for developing notes evolves for students and that they improve from middle school to high school. Scott says typically "the middle school kids might copy and paste a whole bunch of stuff". Then after the $1^{\text {st }}$ tournament realize that the notes are not good. Students usually need a little mentoring to learn how to make effective notes. Scott continues, "We'll help them parse that out to a more reasonable level." Laura says in Appendix K that she tells her coaches that they cannot just present material to the students while they sit and listen. The coaches must sit down at the computer with the students and build the binder with them.

Barbara also comments in Appendix H that the younger students do not really know what they need with their notes. She says that the research related skills of organizing notes, determining what is important, and fitting it all onto a page that can be taken into the event are important. Sophia states that her middle school students usually need parental help in organizing
notes. Overall, Scott says that middle school students will probably have their notes for regionals done in a couple of weeks, but to do it right takes more time than that. "To get your notes right, it takes multiple meets and multiple weeks to get the notes fine-tuned to the information that you think is important."

Usually by the time the students are competing in high school SO events they are more self-sufficient. However, Leslie relates in Appendix L how learning note taking skills is not just the realm of middle school. While she takes all students who are interested in Science Olympiad onto her team, the middle school selects only 15-20 students to be on the team. Therefore, Leslie had a female student who joined in high school because she had never been selected in middle school and high school was the first time she was permitted to join a team. Leslie states that as a high school student the girl is having to learn the skills for doing a testing event that most of her teammates learned in middle school. She is learning on her own how to research her information, study it, try it out, and re-evaluate it before each event.

Referring to the events where students can only take in one page of notes to use and not a binder filled with anything they want, Scott (Appendix Q) comments, "Some of my upper-level kids are very, very advanced at developing their notes to the point where they take a magnifying glass." Scott says that for the high school students "it will take them dozens and dozens of hours to develop the notes that they can take in and fine-tune them." Anne relates that event sponsors tend to comment that students rarely look at their "cheat sheets" because in the process of putting materials into the binder they have absorbed that information. Anne says, "That idea of learning to curate your own resources is very helpful life-long".

Anne mentions in Appendix $G$ another lesson that students learn in the testing event.
This is that no matter how much study or research a student does, the test can have everything
the student did not study on it because it is almost impossible to know everything about a subject. Anne explains that the winning team on a test might get a $50 \%$. So, it is very different from school where the top student is expected to know $95-100 \%$ of the test. "It gets them used to not knowing most stuff and making sort of educated guesses about a lot of things." She sees a lot of innovation in their test taking as well. "It's, you know, how well can I come up with some baloney that sort of fits this question based on a little bit of other science knowledge I have?" Anne and Sandra have previously explained that tests in the events are sometimes too long for one person to do in the event time limit, so students often split the test and consult on questions not in their individual notes. Anne states that even if the second person is just filling in for a regular partner and does not have good notes, they often find they can help by just bubbling in multiple choice questions from the back forward. This teaches that it is better to put something down than to leave it blank because you might guess right. She says, "They'll pick up some pretty good test taking skills out of this."

Matt says in Appendix N that research skills are something that can help them on papers in classes outside of science as well as prepare them for college. Kelly agrees that learning research skills is a benefit for college. She says that it prepares them for "how do I go about researching something he [the professor] may have mentioned in class that's going to be on the test when he only mentioned it and he didn't go into detail about it?" It teaches them to go find information on their own and how to take notes over the information they find.

As mentioned elsewhere, Scott (Appendix Q) likes to take his team to as many invitationals as possible. However, he points out a minor problem with attending multiple invitationals. "With Science Olympiad we run into such varied differences in the same event at different meets." This is because different people may be running the event from one
tournament to the other and have a different interpretation of the rules and a different focus on the material. This means the students must rely even more heavily on their notes and that those notes must be very thorough.

Curating resources can involve more than amassing and organizing notes. Resources can also include the experts that students meet as mentors. A discussion of mentorship is found elsewhere in this paper, but a brief discussion of experts as resources was previously introduced in the chapter by Robert (Appendix O). As mentioned in the Coach Benefits section, he comments on Science Olympiad giving an opportunity for a better student/teacher relationship. This also is a benefit to the students because they know they have that resource. Robert says that any student that he is teaching or has taught in the past or any student that just has a question can ask him for help in math and science. So, even if he is not their teacher for that subject, he says the students who know him and have a good relationship with him come to him for help.

Matt makes the comment in Appendix N that through Science Olympiad students are learning that they need to seek out experts for help and talking with the coach and event leaders makes them more comfortable in talking with adults and teachers outside of Science Olympiad. Matt encourages the students to go seek out these experts. "The high-level math teacher is literally next door and so he teaches Calculus 3 , linear algebra, differential equations so those are like high level math that I am oblivious to - so I know he is cool with students asking questions." Matt states that if a student is earnestly wanting to know something most teachers will never turn them away. He thinks some of the teachers probably enjoy it. He says he knows that "the highlevel math and AP Physics teacher has definitely gotten a little kind of geeked out a little bit on some of the questions that students have brought."

## SO teaches tool use.

Throughout the interviews many of the coaches talk about a place for the team to use and store tools for making the models in the building events. However, most do not comment on the skill level of the students in using these tools or how the students learn to use the tools. Robert (Appendix O ) is frustrated and concerned about the lack of what he considers practical knowledge concerning tool usage in his students. "Kids don't learn it at home anymore, so they don't get the practice. They don't understand the subtlety of what's the best tool to use." He describes how he teaches them to safely use different types of saws and why there are different types of drill bits for different purposes. "They don't even know the terminology let alone how to pick the size and length and the pieces that go together to make what they want to make." He feels these are all important life skills. "I enjoy teaching kids how to do that so that then they can feel proud when you can turn them loose and they can pick the right size bit."

Barbara in Appendix H supports what Robert says even though she has a different personal experience. As mentioned, she is in a farming community so many of her students have skills with things like running power tools, soldering, and electronics. She knows this is not common for all schools. "My brother is an engineer, and he does robotics and he's with inner city kids and we talk about how they don't even know how to use a screwdriver." This supports Robert's experience who is also in a city. Barbara realizes that she is fortunate in this and can have students teach other students these skills. Other skills that Barbara sees students learning are some computer-related skills such as how to do documents and graphing.

As alluded to previously, students generally must learn their events on their own. The structure of Science Olympiad encourages students to be self-reliant. Anne (Appendix G) says, "Just the idea early on that you don't need someone else to teach it to you - you can teach yourself - is really ingrained in Science Olympiad and so I think it really promotes independent
learning and rewards it." The diversity of the events means there is not always an expert mentor around. Anne gives an example of a student who competed in the robotic arm event. Because she describes herself and the other coaches as being so bad at helping him, he and they could not figure out how to modify one of the approved kits to do what was required by the event rules. The student wound up building a robotic arm from scratch by himself and, because of his innovativeness, earned an internship with NASA. "It really kind of forces the kids to figure stuff out themselves."

At the high school level, most coaches indicated they try to let the students work on their own. Scott (Appendix Q) says he tries to act more as a coordinator and let the students be selfsufficient. Leslie in Appendix L that her kids are usually rather independent in building their binders for the testing events. Kelly (Appendix J) says that when her school sponsors and invitational, she puts students in charge of setting up different events for the sponsors. She says then they take responsibility for understanding the rules of that event and it makes them better competitors in that event. They understand that they must take responsibility for their own independent study.

## SO improves written and verbal communication skills.

Science Olympiad helps students improve both written and verbal communication skills. Kelly in Appendix J gives Forensics and Write It Do It as examples of events that improve writing skills. "They have to write such a deep analysis and having the skills to break everything down and write it well because they get so many points for what they wrote, I think is important." She comments that students do not think these are going to be hard categories. They especially think that with the Write It Do It event. In this event one student is given a built structure and must write a set of instructions for how to build it. The second teammate is given the written instructions and a set of unassembled materials and must recreate the object as
accurately as possible (Science Olympiad wiki Write It Do It). "It's so funny because you don't think that would be a hard category and just writing down how to build something, but it's amazing when they realize how many steps they forgot to write down."

Students also must learn verbal communication skills. Students need to communicate issues they are having with their partners both to the partner and the coach. If a student needs help, they must learn to ask for that. Matt in Appendix N mentions what he calls "soft skills". He lists items such as learning to make eye contact, talking with complete sentences, being adaptable, being able to problem-solve, being a teammate, and being a leader. "These are all good skills that I think kind of complete the education process for a young person." He states that it is hard to teach these skills, but he sees Science Olympiad providing a setting conducive to students.

Additionally, learning to talk with the coach and event leaders makes them more comfortable in talking with adults and teachers outside of Science Olympiad. Matt gives an example of a student who had trouble communicating. "They are interpersonal, so they had trouble expressing how they felt. They had trouble communicating in a comfortable way with individuals." The student came back to visit him, and he noted that the student had really blossomed. "I can't scientifically identify and say that it's because of Science Olympiad...but I'm sure it has probably a small factor in their ability to communicate and talk to people and express how they feel in a very comfortable way." Research skills are another thing that can help them on papers in classes outside of science as well as prepare them for college.

Sophia (Appendix R) says there are all different skill levels on the team, but that creates opportunities for some students to develop leadership and mentoring skills. "We have a lot of older students who help and tutor the younger students." She explains that it is important that a
student learns how to study and learning from an older student on the team teaches the older student mentoring skills while the younger student learns the needed study skills.

In addressing the specific skills that a student would learn in Science Olympiad that crossover into the traditional classroom, Matt mentions that the students learn skills involved with problem solving. This helps them do these same types of tasks in a classroom setting.

Even outside his favorite hands-on building events where it is more obvious, Robert (Appendix O) sees the ability to apply knowledge and the skill of problem-solving as crucial for students to be successful competing in their events. "They have to kind of go outside of sort of the standard program that you get in a curriculum and think a little bit farther." "It's good to have pure academic knowledge. You know, that's a good base. But, unless you know how to apply it and you know how to problem solve with it, it's kind of a wasted skill."

Several examples show that peer teaching is an integral part of older or more experienced Olympians leading their fellow participants to success. Leslie in Appendix L says, "I know my son took the fossils test last year and this year he was in a different event." She said her son would check in with the new participant periodically and ask, "Hey! What else do you need to learn?" Or the new participant would ask her son, "What have you seen on the test?" She says that collaboration with peers helps. "Sometimes I'll see my high school kids work their way somehow, magically back down to the Middle School building and they'll be in their STEM room talking to them about the events that they're doing and if they are similar."

Barbara (Appendix H) mentioned previously that students teach other students skills needed for the building events, however the mentoring goes beyond tool usage. Barbara tries to pair older students with younger students in the same category so that the older ones can teach the others. "I try to put some $9^{\text {th }}$ graders with $7^{\text {th }}$ or $8^{\text {th }}$ graders to teach them. She says they do
not like it too well, but she tells them, "You've got to teach somebody what you know because you're going to be gone."

## SO teaches students to cope with disappointment and the notion of unfairness.

Scott relates in Appendix Q experiences where his team have had instances where rule interpretations went against them, and the students had to deal with feelings of being treated unfairly. Rather than dwelling on these as bad experiences, Scott used these to help the students understand that life does not always seem fair, and one must look at what can be changed, improved, or learned from the experience and move on to the next thing. He says that learning to deal with these types of life experiences is a valuable part of Science Olympiad. He describes the kids talking about how unfair they think it is and he asks them, "We know now. How are we going to take care of this?" Scott says those are experiences that help build character. "I think the building of character and that efficiency I talked about, and the preparedness pays dividends for the leadership qualities they'll need in life."

Sophia (Appendix R) says, "I think a lot of these kids are used to getting what they want, so when they don't get the events or the partnerships that they want, sometimes that can be a bit of a problem." She explains that sometimes multiple students want the same events. Sometimes the events they want conflict with each other when the tournament schedule comes out. This has been more difficult with the virtual format than before. She finds it is easier to manage the student expectations when she has everybody together in person because she can remind them, "Yeah, I know you've been studying for these four events all year, but you have to be prepared that on the final schedule these events might conflict, and you might not be able to do both of them." She says the students must learn to deal with that kind of disappointment and frustration, but she implies that she views this as a growth opportunity. This is not just because they learn to
deal with disappointment, but as previously mentioned they must pick up a new category and learn something outside of their comfort zone.

## Science Olympiad offers opportunities for leadership and teamwork.

Coaches gave several examples concerning students learning to work together and the other benefits of being part of a team. Since every event expects that a pair of students will compete, students must learn to work closely with at least one other person. Some events allow three to compete, which adds another person into that close mix. Additionally, the logistics of a 15-member team to cover 23 events means that most students will be competing in two or three events. Sandra in Appendix P sees this as mimicking a workplace scenario, "Well, every event has at least two students working together, and it really is a great training for the workplace." Mark (Appendix M) agrees that it teaches students to work together. "They've got to be able to work with a team - work with a partner." He comments that personalities can be an issue. He indicates that some of the students do have trouble working together. Those that habitually procrastinate may find that their partners will not tolerate that and tell them, "No, I can't work that way". Sandra says, "So, just the experience of having one person that you work closely with and figuring out how to work with that other person on that event is beneficial." In cases where a leader type is put into an assisting position in a pairing, it can lead to some conflicts where both students want to take charge. An example is that a student who is the lead expert in one event may not be the lead expert in a different event in which they compete. So, that student must learn to switch roles from leader to follower in the different event situations. This provides an opportunity for personal growth in learning to work with others.

Students learn to be flexible in working with others because they often will not be paired with the same person for every event. This may simply be due to the fact that the same pair of students may not be interested in all of the same events and want to compete in different things.

Other reasons may have to do with a student missing a tournament due to illness or another activity conflict. Outside of invitational tournaments, coaches may make strategic pairings to build the best competitive team. Beth (Appendix I) explains, "If you're paired with somebody at an invitational, you may be paired with somebody else at regional."

Additionally, if a student is having problems with a partner not doing their part, they have to make decisions on how they will handle it. Do they want to mention the issue to the coach so that the partner's parent can be contacted or do they decide to mostly do the event on their own? Sophia (Appendix R) thinks this is a good people skill challenge.
"Well, every event has at least two students working together, and it really is a great training for the workplace," Sandra says. "You know, in the workplace you may have a whole floor of people who are part of your team, but you may have projects where you're only working with one or two other people at a time." Additionally, she sees Science Olympiad mimicking a real-world workplace scenario. "Also, it's supposed to help mimic a scientific community where you have one or two people that you're working on a project with but then you share your results with a whole group of people and you have that feedback," says Sandra. "So, just the experience of having one person that you work closely with and figuring out how to work with that other person on that event is beneficial."

Beth says in Appendix I that she has seen her students bloom over the years."My little sixth graders come in squirrely as all get out and can't focus on anything and, oh my goodness!" Then when they are in high school, she sees them participating in Science Olympiad as well as other outside things. She says they are "enjoying these outside things, doing, you know, learning more things, and presenting themselves and -and working - working together as a team". She believes it will help them do well in their future. Sophia (Appendix R) likes to encourage the
social aspect with her team as well. Pre-Covid they did a variety of things. "We have the kids plan parties and get-togethers and usually after the meetings they play soccer outside in the field."

Anne (Appendix G) always tries to avoid sending a student into an event alone. She would rather send in a second student who thinks they know nothing about the topic or who has never been in a testing event because they at least get some experience and see how it works. She says sometimes they find they can help. Anne explains that occasionally a test is too long for one person, so the second person can help by just bubbling in multiple choice questions from the back forward. "They'll pick up some pretty good test taking skills out of this." Beth states that especially her students in the building events will ask for someone to go in with them if a partner does not make it to the tournament. Leslie (Appendix L) also tries to make sure that there are always two students in each event. Sometimes at an event someone will get sick and then she must find someone last minute to partner. "I always make someone go with them. Even if they've never done anything with it." She feels that it is important for moral support at a minimum.

Leadership roles develop in these pairings as either the more experienced or the older student in the pair will take the lead for that event. Sandra says, "... you'll see it even with the two-man teams going into an event. You may have one person more organized about information and the other one not." Leslie also says she notices that there is usually one student who takes the lead in each one. Sandra says when she sits in on events, she often sees one student take the lead for the pair. That student will look at the test and say to the other, "Okay, here's our game plan. This is what we're going to do." The students are working under a time constraint, Sandra in Appendix P explains, "They want to get started and get things done as
quickly as possible. That requires some type of leadership for making those quick decisions." Student pairs can split the test and each answer different questions and then discuss any questions about which they are uncertain if there is time remaining. This helps the pairing have a better chance of finishing all the questions within the time limit and still have some time for rechecking.

Sometimes the coach may put a student into an event as the second person on the team to assist the person who has more experience in that area. Beth (Appendix I) has a story to tell about this. Because she takes all those who want to participate, she has had students join the team who only want to compete in one event at invitationals with no plans to ever be on the competitive regional team. "Oh, my goodness," exclaims Beth. "At regional once we threw a guy from the invitational team who hadn't practiced with us at all into an event." This student was participating in Science Olympiad but was not trying to be on the team qualifying for the State competition. "Somebody got sick that day and the partner [who was] left doing the event didn't want to go in alone. So, we grabbed this guy, and they went in and actually medaled. It was great!"

Respect for teammates comes from the realization on the part of students that you cannot do it alone. Anne says in Appendix G the students talk to her about their experiences in testing. She relates a student saying to her, "I got in there and I had prepared really hard on my part of the information, but then the test really was a total miss for my topics and my partner had to do almost all of it." In a case like this, the student is very glad that their partner prepared as hard as they did and on different topics. They learn respect for their teammates and the skills of another person who might be different from them. Anne thinks this helps a student be open to diversity.
"Relying on someone in competition who might have different political views than you or might look different than you are a really great basis for future understanding."

Matt (Appendix N) sees Science Olympiad as being a place where students work together who would not normally be together in a classroom or social setting. With a large student body of over 3,000 at his school, even those students with similar interests might not be in classes together. Anne supports this when she says that her best friends when she was a student were her teammates. "And they weren't even people I was close to before I joined the team." She sees the same pattern with a lot of her students. "Sometimes kids are already friends when they come in, but sometimes not - more often not."

Anne acknowledges that sports teams provide a similar exposure, but she thinks Science Olympiad is more multi-level in these experiences. She comments on her own experience as a student and how she made "these friendships studying together, sitting on the bus together for hours". She explains how students are not supposed to know who is on scholarship to the private school and who is not, but students seem to figure it out. So, some members of the team are hanging out with others who are not as privileged. "Kind of gets kids out of their normal social groups." When she was a student, it was rather public about who was on scholarship. She says that was her source of friends because Science Olympiad was what they had in common. They came into the school and said, "We're all smart. Let's join the Science Olympiad team." They all hung out together and were from diverse backgrounds. She says her parents commented one night that the group of them were like the United Nations because they were so diverse. She still sees this diversity as a characteristic of the Science Olympiad team. "It's a beautiful thing," she added. Additionally, the school does try to recruit a diverse population and they use the fact that they have a successful Science Olympiad team to appeal to some ethnicities. Anne had a

Chinese American student interested in joining the team and she confided in Anne, "You know, in the Chinese community around [the city] it really is cool to be in Science Olympiad." Anne did not specify which others, but remarked that some of the other minority communities have similar views. "I love that we're cool." It comes back to the comments about respect from earlier and the fact that the partners divide up their work. Anne says, "You start really relying on each other and you really respect what your partner brings to the table."

Due to classifications for funding and support, it is important in some schools for Science Olympiad to be classified as either a team or a club. Those using the club format often use the traditional club officer format with president, secretary, and treasurer being mentioned. More commonly, the team classification is used due to the competitive nature of the organization. In some cases, the officer titles may still be applied, but team captains or different designations are employed.

Kelly (Appendix J) runs her teams with two captains per team. The captains are upperclassmen and usually members of the "A" team and have competed before. Each team votes on who they want to be their captains. This means that for the B and C teams, the captains are most likely not competing with that team. This structure provides opportunities for several students to develop and practice leadership skills.

Matt in Appendix N has his team organized with several leadership roles for which students can apply. He names president, vice president, treasurer, and project manager for these roles. He has developed a process like a college or job application where students must explain why they would be good in that role and procure three letters of recommendation. "There are definitely leadership opportunities and there is definitely modeling of leadership going on in Science Olympiad from a lot of different angles not just me." Matt tries to model leadership, but
he tries to let the president be the leader and influence the team. "That's something else that I very much enjoy seeing is students just take that role and go with it and really become awesome, awesome leaders." He says it is fun seeing the different styles of leadership.

Matt personally thinks the project manager is the most important role. This is a role he has created, and it seems unique to his team. The project manager is the student who communicates with each participant and decides which events everyone is participating in. Matt likes the project manager approach better than the more common practice of the coach keeping a spreadsheet of attributes and likes for each student. Other coaches in this study use the spreadsheet approach to match students' interests and abilities to events. This approach will be discussed further in those cases. Matt says, "I just leave it up to the project manager because they have a better feel and understanding because they're in the mix of all those different school events that are occurring and they're friends with all these people too." He implies that the students make better team pairings and event assignments than he would. He keeps an oversight and if he sees anything he thinks is going unnoticed or needs to be addressed, he talks to his project manager about it. "If you treat a student like a leader and if you treat them like an adult, they'll start acting like an adult and act like a leader."

Mark (Appendix M) gives an example where he watched an unlikely leader emerge. He had one student who he tried to get involved with the middle school competitions. "Super sharp kid, but he is quiet and shy." Mark was not successful in getting the student involved in competition until his sophomore year. "Then he kind of got a little involved his sophomore year and then by his junior and senior year he was a leader of it." Mark says that if you just spend time with students they develop. "By the senior year that kid you couldn't shut him up, you know. He was a talker and came up with some really cool quips."

Sandra, in her role as State director, confirms comments by some coaches during their interviews that some schools have student coaches and are not run by an adult. In Appendix P she explains that there are several schools where the Science Olympiad "coach" is just an adult sponsor at the school who signs off on the paperwork and the actual person fulfilling the role of holding team practices, putting together the team and directing students into events is one of the student team members who has taken on that leadership. "That takes leadership, too, because that team captain has to take on those responsibilities that a coach would have." She describes some of the responsibilities as selecting the team members, organizing the team, and handling team registration for tournaments. She sees teams with an active adult sponsor or coach providing the more traditional leadership opportunities for the students. "I have seen where students will be put in charge of different things like making sure all the other students get their equipment that they need or keeping other students on task with the scheduling."

Sandra explains further her workplace analogy. "You know, in the workplace you may have a whole floor of people who are part of your team, but you may have projects where you're only working with one or two other people at a time." Additionally, she sees Science Olympiad mimicking the larger professional scientific community. "Also, it's supposed to help mimic a scientific community where you have one or two people that you're working on a project with but then you share your results with a whole group of people, and you have that feedback."

Beth explains in Appendix I that there is a community effort in getting the whole team to a competitive level. The students who are in the building events end up having to enter some of the testing events as well to cover all the events. Everyone who starts off on a build may not get to do a building event on the competition team because their build may not be the best. "I love our team because even if they're not on the scoring team, they still all work together." She
describes that she might have three different teams doing protein modeling for example and they work together. "Then we'll have a time where we test our builds and see which [pair is] doing the best and then they all go for helping with that [pair]." The best pair will be on the competitive team. The others might still compete at invitationals, but they will put effort into helping the competition pair improve and be more prepared to compete.

Commitment is another thing Kelly (Appendix J) sees Science Olympiad teaching students. "That maturity of staying committed to a team or understanding once you give your commitment you cannot decide to go to something else because it is more fun." She says this is harder for middle school students because they are so young.

On the topic of how he sees teamwork happening, Mark in Appendix M says, "Oh, some of the kids are just interested in medaling and then, of course, the team part just kind of happens." Laura (Appendix K) holds two mandatory whole team practices to encourage team cohesiveness. This is because during the year Laura's pairs and trios meet with their individual event mentors on different nights of the week and the whole team is rarely together. For these afterschool practices, the mentors will often provide snacks or cheap pizza. Likewise, at the whole team practices, Laura makes sure there is food present. She says that the food helps the kids get closer because they stand and talk to each other while they eat.

Finding a place to belong is mentioned by several coaches as an important experience for students. Being part of a team gives the students a sense of belonging and acceptance by others. Mark believes that the students need a place that belongs to the team. "Kids like that, that are doing those things, must have a homeroom. They got to have a feeling of a place to belong." Since Mark is not a teacher at the high school, this place cannot be his classroom, but the high school did provide a space for them to keep their tools and specialty things. "It was just a room
that we kind of got assigned to, but it had a nice little storage area to it. I made tool benches and work benches and stuff so the kids could roll things in and out." The students also use the room for robotics and some other things. He says that group of students just said, "That's our room". They go there and work and they're there at night. He says that being able to trust the students is a big thing because there is a delay between the end of school and when he can get there from the middle school.

This room is where the teamwork and camaraderie are evident to Mark. He says that it is just one big room, and they all get in there and "chit chat back and forth and they try to give each other a hard time". He sees that here is where the leaders of the group reach out to the other students and talk to them. For example, the bird conversation he gave as an earlier example happened in this environment. He says that since he has a small team, he does not have a structured club with officers. He laughs and says that they are a little bit more of a touchy-feely group.

Scott also talks in Appendix Q about the importance of a room at school. Scott does not teach at the high school, so the team must borrow a room from one of the teachers who has allowed them the use of her room after school for about eight years. The room is mostly a place to house a cabinet of resources where the students can deposit tests from previous meets. "She will let me know if she's not available for the kids to come work, but at most we might have one or two kids go in, get some old tests, get them copied, and then go on their way." Scott thinks that a room where they did not feel like they were invading someone else's space would make the team better. He explains his ideal situation, "We'd have a dedicated room where the kids could meet and I would be there after school which I think is probably the next step to make us a top - consistent top three to five team at State."

In order to get practice in during the school day, Leslie says in Appendix $L$ that some students will try to work in a few minutes at the end of class times. For this to be possible they need a place to work where they are not interrupting a class. "The STEM room is a separate room next to my classroom, so if they had time during the day, they would come down and ask to have the keys to the STEM room." Leslie was able to start the program at her school because the school had received a STEM grant from a local business just prior to her being hired. This grant provided for the outfitting of a STEM room. "That STEM room was set up for us pretty well, but the materials are starting to run out."

Because Sophia's team in Appendix R is a homeschool group, they do not have a school where they can meet. She explains that each student must pay a $\$ 100$ fee each year so that the team can rent a local recreation center for their meetings. They can meet outside of the rec center for free (and had to during COVID because the center was closed) but during the winter or when there is rain, this is not a good option. She feels the weekly meetings are important because it is easier for her to convey information to the students when they are together in one place, and it is also easier for her to see how they are progressing in their preparations. She also comments on how the students will often gather at the rec center for social activities. "We have the kids plan parties and get-togethers and usually after the meetings they play soccer outside in the field."

Scott also explains in Appendix Q how having a room is also important at a tournament. Most tournaments provide classrooms that teams can use throughout the day to go to between events, eat, and socialize. He says that it is important to the kids to get to the site and scout out where their room is. "They've worked all year. They've worked hard. They deserve that early out to get down there and make them as comfortable as possible for state." He says that his
principal will allow them to leave school early and even pay for their lunch on the trip. At larger tournaments such as state, there may be more teams than rooms, so rooms are on a first come first served basis. "Getting a home room at state is a pretty competitive item. They don't allow you to reserve them." He says he has had a parent volunteer to arrive there at 5:30 in the morning to get the homeroom for them. "That's good morale and emotional support there."

Some coaches mentioned how there is a sense of family among the team members. Travel is important to develop that team spirit and camaraderie. According to Laura (Appendix K) the cohesiveness of the team forms when they are doing things together. Laura mentions how the bus trips are where she really sees the grades mixing. She says that they are riding together, and they are playing together. Prior to Covid-19, Robert's high school would run two teams and the middle school would run three or four teams. This has not changed that much, but he sees some students being less enthusiastic because of the virtual format. "Virtual tournaments are quite honestly not very interesting because you are all by yourself when you are taking the test." He explains that when the students are there in person, they are there with their teammate testing in the room together and then later running around to watch all the different events and different things together. Laura says that on the trip she observes how they mix. "Sixth graders tend to stay with sixth graders. They really do. They're just not there yet." However, she sees that by the end of the year, the sixth graders have gotten closer to the older students. "They watched them and everything and they were pulled in, you know. They make that connection with the previous $7^{\text {th }}$ graders and so as $7^{\text {th }}$ and $8^{\text {th }}$ graders they're together." Laura indicates that the bond becomes somewhat like a family. "The Science Olympiad kids are pretty protective of each other when it comes down to it. Absolutely, they protect each other." Scott says, "Some of the
kids, it's their first time away from home. So, we kind of have to play the parent or big brother and big sister role which is nice."

Leslie says in Appendix 1 that her students enjoy the travel to tournaments. "I have 6 or 7 kids that are really dedicated to the competition aspect. The rest just kind of show up because they want to be involved. It's more of a camaraderie thing," says Leslie. "They like to go. They like to hang out and they're with other kids that are like them. That's such a big deal because they'll get together with kids from other schools."

Robert (Appendix O) says that in the past when the team went to nationals, they would take an extra day and do some sightseeing before coming home. Currently nationals are still virtual. "So, you're back to, you know, competing by yourself in a classroom, you know, for that event and not quite as thrilling." Robert says the students spend most of their time at tournaments socializing as a team. The students do get some exposure to students from other schools during the tournament time, but he would say that $90 \%$ of it is within team socializing. This is important team building time that the students always look forward to yet missed out on during the quarantines.

Sophia says in Appendix R that even though her students are all homeschoolers they do a number of activities. "They don't just sit at home." However, she feels that the science team offers them a lot of opportunities for team building and networking. A lot of the same kids are on the math team, so that and science team activities are where they build their community. They do their competitions together and they meet the other students who will be doing AP classes with them. The team is an important networking place for them.

Robert says that the invitational tournaments are important for the team to develop camaraderie and have fun together. He says that doing things together like traveling, being on
the bus for six hours, being in the hotel, and going out to dinner are all team socializing activities that the students look forward to and consider fun. He does not state that he sees new friendships forming but sees it as an opportunity for friends to hang out together at an activity outside of school. "They're with their friends quite honestly because, you know, all the smart kids hang out together." He says at the tournaments the teammates run around to all the different events together. When they go to nationals, they try to arrive a day early so they can walk around and explore the hosting campus. It is also a tradition to take an extra day to come home. Robert says, "I found out the history, you know, they've been so many times to the national tournament, they always plan to spend that extra day sort of as a reward for the kids that hung in there to go explore these awesome tourist places wherever the national tournament was." He says that the year he went, they took students to Niagara Falls. "It's a social activity for this travel and I think that helps solidify the ownership of the team."

Sophia likes to encourage the social aspect too. Pre-Covid they did a variety of things. "We have the kids plan parties and get-togethers and usually after the meetings they play soccer outside in the field."

Kelly says in Appendix J that the students talk about and use the trip as a recruiting device to attract new members. "They usually are the ones that are recruiting and talking to the kids about how much fun they have when we go on trips and stuff." Travelling together is a bonding experience for students. Anne describes how at the hotel the rooms are all next to each other and they leave the doors open and wander from room to room practicing events. "Those kids really bond over that." She observes students stepping up to the responsibility of looking out for each other. "You see a lot of kindness." Travelling also allows for interaction with other schools. Anne does not often see direct friendships formed with students from other schools
during invitationals, but longer trips like state or nationals offer better opportunities for that. If other schools stay at the same hotel, then she sees students from different schools sitting down and talking. She says, "And that's really a cool thing." As a student, she says she always ended up making friends with their rival school when both teams went to nationals.

At tournaments, Robert says that they get pumped up about doing well and cheering at the awards ceremony for the team and the individuals that medal in their events. The camaraderie and sense of team spirit was evident to him even at the invitational they did not win this year. "Just the fact that they could cheer for individual team members that medaled was kind of cool and so we have that camaraderie within the team."

Some teams have an official club organization at their school, but most of the teams in this study do not. The coaches commented that whereas a formal organization gives designated leadership roles, the nature of the Science Olympiad team allowed many different leadership roles to develop. Each team develops what works for them and the style may change from year to year as the students on the team change. It seems that the overall view is that this allows more students to experience moments of leadership as opposed to designating only a few to be responsible for all decisions. An example of these different leadership roles is that some students will take responsibility for making sure other students, especially younger team members, are at the event rooms on time and have all their equipment. Another example is that older students will often mentor younger students in an event area that they are no longer competing in or will take a younger student as their partner in an event the younger student is wanting to learn.

Robert runs his team with three co-captains. Two of these students are additionally designated as the team secretaries. "They keep the administrative records, and they take attendance lists and things like that and keep track of that." The team captains are all seniors.

Part of the responsibility of the captains is to motivate and to lead the other members of the team to participate and be on time. Robert says that is not something the coaches should be dictating. "We need the students to feel emotionally, uh, responsible for the team and to make things happen." When the team travels to in-person tournaments, the seniors are each assigned to be responsible for groups of students. "It's an important life skill for them to learn how to do that."

Another practice that can add to the cohesiveness of a team is team member mentoring. The mentoring of younger students by older students and pairing a more experienced person with a newer person on a team for an event means that students who might not otherwise know each other are working together. Matt (Appendix N) says, "When you have a common goal and you work together for weeks and weeks and weeks and months on end throughout the entire year, you develop a kinship." To relate back to content knowledge, this mentoring ability was reported by some coaches as transferring to the classroom and benefitted students who were not on the Science Olympiad team because the Science Olympiad participant would mentor their classroom peers in knowledge gained through Science Olympiad.

Anne explains in Appendix G how as a student Science Olympiad student mentoring created a great way to find other students who were like-minded in some ways but different in other ways. Because her school team has a tradition of pairing upperclassmen with underclassmen, it helped her to get to know upperclassmen. The high school also sends students over to mentor middle school team members. These high school mentors become the leaders of the team and there is an accountability that develops. The mentor cannot let their mentee down and vice versa. "You get a sophomore or a freshman who some senior has been nice to, and they are going to work extra hard." They do not want to let their leaders down. Friendships can grow out of those mentorships. She says, "My senior year one of my best friends was a ninth grader I
met through Science Olympiad". After graduation Anne visited her while she was home on college breaks, and they remained friends all through graduate school.

Matt feels that gaining the team experience is an important benefit of Science Olympiad participation. Even though he says he does not really see a typical student type for Science Olympiad, he does say that most of his Science Olympiad students are very academic and not typically athletes. "It's nice to have a non-athlete actually be able to compete like an athlete would in an academic style situation." He then points out that Science Olympiad teams are not just for non-athletes. He does have athletes on the Science Olympiad team by giving the examples of the team president who is a black belt in taekwondo, another team member who runs track, and a third who plays volleyball. So, every student is unique, and everybody brings their own expertise to the table. In general, though, Matt likes the opportunity Science Olympiad provides students who would not otherwise get a team experience. "They get to experience [in] team play, and they get to experience winning and losing and camaraderie and all these other things that you learn in an academic setting."

Sophia's high school team in Appendix R also elects officers and mostly runs their own team. "It's a chance for them to get experience working on committees and negotiating with each other and organizing things like that." Sophia says that at the meetings they will have the students make presentations or will have a guest speaker. These speakers can include anyone that they hear about who is doing something interesting. "Very often those presentations are not related to a Science Olympiad topic." The university nearby has a "Present your PhD" program. "They'll send graduate students in to meet our students and do a presentation." She thinks it is just great exposure for the students to hear about the things. She tries to at least once a year have
a speaker from the community college to come and talk about how to do dual enrollment so the students know about those opportunities.

The inference that Sophia shares is that nearly all her students are planning on attending college. She mentions how being on a competitive team is good for their college applications and how she writes a lot of college recommendations.

## SO competition gives participants a sense of success.

When asked to define success, Laura (Appendix K) says, "Oh! We don’t take last place." She laughs. "I'm not really kidding. There's a saying about second place not being the best place. I don't care." This appears to apply to invitational tournaments because when she talks about the regional tournament, she reveals her expectation that her team will finish in the top ten. "If they are below the top ten at Regional, that's the time to have a pow-wow with the coach and find out why they didn't make it in the top ten." She will try to get extra help to bring them up before the next competition. "I don't want to be last. That's all. Middle of the road is okay, but last is not." She continues, "When I look at what they learn and what they know when they walk away from this, top ten I'm happy."

Witnessing student success is what makes Barbara in Appendix H want to keep doing Science Olympiad every year. She describes success as "the look on a kid's face when they accomplish something they didn't see right off". She says it is when the student says, "This is never going to work" but it does. "You know, when their bridge holds all the amount [planned for] or when their car hits the mark or when they get a medal." Barbara talks about the excitement when her team who could barely make it to state had two girls win their category at state. "We were so excited that we could do something like that." She says she just enjoys watching students do things they didn't think they could do and to just compete even if they only
do okay in it. "It's rewarding in itself." After describing this she pauses and says, "I can't talk because I am tearing up over here."
"The amount of medals and the place we win with the trophy don't really matter as much to me," says Beth (Appendix I). She wants to see the kids happy with what they have done and explains that she feels successful when a kid gets a sixth-place medal at a Regional event and she hears them say "Oh my gosh! I got a medal!" and be truly excited about it. "That to me is as much success as like getting all first." She shares that she had a couple of seniors that when they graduated, they told her, "This is the only place I've ever gotten an award". The awards structure is one of the things she really likes about the Science Olympiad competition. "The way that Science Olympiad does it, you can get medals for all the different events that you do." She explains that each event gives individual student placings in addition to the team having an overall placement. As for coaching a successful team, Beth says, "I don't believe we've actually ever won regional, but we've gotten second place at regional which was good." She says that they generally fall somewhere in the $4^{\text {th }}$ to $6^{\text {th }}$ placing in the team competition. "It gets us to state [level competition] and they've learned something." She thinks it is success when a student comes in and says, "I got a bronze in Chemistry."

Leslie (Appendix L) teaches in a state where there is no qualifying tournament for state and any team wanting to compete can participate at the level of the state. She says she has not coached a successful team because she views a successful team as a full team that can cover all 23 events and she has not had that yet. "As far as the competitive coach in me, not being able to take a full team to the Science Olympiad event is frustrating."
"Every kid has different levels of success," states Mark in Appendix M. He says that he feels successful when he hears the kids come back from a meet and say, "Yeah, I did this". He
also says it is a sign of success for him when the kids come back and tell him, "Thanks". His comment on the competitive success history of his team is, "I'm just lucky that we have been at the State meet and top four every year. So, I guess, well I was just lucky with the right kids."

Sandra's gauge for coaching success in Appendix P changed with the team she was coaching. When she was a volunteer coach for a middle school, she was coaching a brand-new team. Her gauge of success was that students were regularly attending practices. "It showed that they were involved and dedicated and usually that involvement and dedication would show through at the tournaments as well." When she later coached at the high school, the team was established and already had its own definition of success. "They had previously gone to a few national tournaments and had even medaled at some of the national events. So, success for that team, obviously those students who had gone to nationals, success to them was going back to nationals." She says her personal gauge of success for the team was that they were having fun. "They had so many other stresses going on. As long as they had fun, I saw that was success." Scott (Appendix Q) says that superficially his gauge of success in winning medals at State. Aside from that, he says that he feels he has coached a successful team every year. "So, I think personally that the life experiences that the kids get is, at minimum, equally as important." He thinks his assistant coach would agree with him. "Winning events at regionals and potentially state is the icing on the cake that they've built through the whole year, and I like icing." He laughs.

When asked what she defines as success, Sophia in Appendix R responds, "Success is students discovering new areas of science that they enjoy, building friendships, pushing themselves academically and working successfully with partners." For her as a coach, she says,
"Success is making sure the students have a positive experience and, very importantly, making sure that someone has the necessary tools to take over when I retire after this year."

Kelly in Appendix $\mathbf{J}$ does not give a direct definition of success, but by inference she equates success with winning because she talks about her winning team as "successful" and the fact that her school recruited her because she was successful with a track record of winning teams at both of her previous schools. Most of the coaches in this study indicated that winning is equal to success in the eyes of their administration as well as the surrounding community. This is a factor several of the coaches refer to when they talk about getting support from their school and community. Once they showed the program was successful by winning, it was easier to get multiple types of support.

Mark (Appendix M) thinks that success is something the students also need to feel and Science Olympiad provides a means to achieve that feeling. Even when students do not win, coaches discuss how an improvement in placing from one tournament to the next reinforces a sense of progression in knowledge and or skills for the student. Anne in Appendix G says a little bit of success will encourage students to try more. For some, the concept that winning is not a complete gauge of whether they are knowledgeable is a valuable lesson. Learning that just because someone else is a little better on one day does not mean that they are less intelligent can be a valuable lesson in how to maintain self-confidence in the face of disappointment.

Leslie (Appendix L) says that when the kids are not successful in events, they put effort into learning how to get better for the next competition. She says they will come back and say, "This is what I'm gonna do next time." Due to the distance of her school from all the tournaments, her team does not stay for the awards ceremonies and has their results mailed to them. She says the students anxiously look forward to seeing their results. They will look them
over and tell her, "Okay, this is what I need to improve." Leslie says, "They're very selfmotivated in that way."

A series of successes also build self-confidence in students who started off thinking they lacked knowledge in a particular area. Several examples show how students who did not feel that they were very smart or not good at STEM in particular were surprised after competing to find that they did have knowledge and could succeed. Anne explains in Appendix G that the winning team on a test might get a score of $50 \%$. So, it is very different from school where the top student is expected to know $95-100 \%$ of the test. She says, "It gets them used to not knowing most stuff and making sort of educated guesses about a lot of things." She sees a lot of innovation in their test taking as well. "It's, you know, how well can I come up with some baloney that sort of fits this question based on a little bit of other science knowledge I have?"

Barbara (Appendix H) sometimes has students who are reluctant to take their build to a tournament because they feel it is not like something built by an expert. Barbara tells them, "We go with what we got and I know you built it." She will acknowledge with them that it may not be the best-looking device but encourages them with "it's going to be something you built and I hope that you're proud of it because you did it and I didn't and your parent didn't." She is very insistent of this because when the student does win or place with either their build or in a test, she wants them to have "that pride of doing something that maybe they didn't realize they had in them."

Laura has two examples in (Appendix K) of girls discovering unknown abilities. "I can tell you a story of a young girl of Vietnamese heritage," says Laura. "Oh my gosh, could she draw, and she wanted to do bugs." Laura relates that she did not expect too much from the girl and her partner. "Well, you know what? She took first place at State." Laura said that the girl
came up to her later all excited and said, "I didn't think I could do anything but draw." Laura continues with another girl also in the entomology category who really struggled in school. "Especially in math she struggled, but she was good at bugs! I don't know what it was. She just got it," says Laura. "And it's those kinds of things that you watch. The ones that are the underdog or they struggle in the classroom and yet they find that one building event or that one thing they do really well in." Laura says they gain confidence because now they can do things they did not know before. "That creates more confidence and with confidence you become a good leader."

Matt (Appendix N) says, "Like, I love seeing students try new things and then decide, "Okay. I definitely don't like that". This seems a little counter intuitive. He explains that he had a pair of students who were not comfortable building things. But he and the project manager said to them, "Hey, you might try this". The students gave it a serious try and Matt says, "They were surprised how well they did even though it wasn't something that they were, you know, too keen on to begin with." He says that gave them "pride in what they did." He does not claim that the students fell in love with building things after that, but states that getting good results was a vindication of their hard work.

Scott in Appendix Q says, "I think that's probably one of the best experiences I've seen in my teaching and giving the kids is that experience of 'Man, we did poorly,' and then they're called for second place." He says that little surprise makes them think, "Wow, I guess we didn't do as poorly as - as the other schools." He likes to take that little bit of negativity about maybe everyone did bad and make them rethink it. He says he will tell them, "Well, maybe you just did a lot better than you thought."

This opportunity to try things and make mistakes in a low-risk environment is one of the benefits Anne sees in Science Olympiad. Even though it is a competition, she considers the environment low risk. "Does it matter if we come in second or fourth at a local tournament? No." She thinks it's sometimes better when they do not win because that can be motivating to the students. One thing that keeps it low risk is that anyone can be in Science Olympiad. Some invitationals allow more than 15 students on a team. Anne explains that they let whoever wants to compete and then just count the school's top score in each event. She says that the national organization is starting to discourage that practice which makes it hard for her to keep the program open to anyone. "We want people to try it and get better. We don't necessarily need them all to be future national champions."

## Competition makes the science activity fun for students.

The focal point of all the students' hard work comes on competition days. The whole day of competition is conducive to the team having fun together. Coaches give examples of different aspects of the day that make it fun for themselves and the students. One of the things is that each team is assigned a room that is their home base. They order food or parents bring food and they eat together there. Different events are scheduled at different times, so students who don't have an event at that time will go to the build events that are open to spectators and cheer on their teammates. Matt (Appendix N) says, "It's just a fun day to kind of spend doing some science."

As previously discussed, placing higher than expected is obviously fun and winning recognition is vindication of the work and time the student put into preparation. The awards assemblies pre-Covid were exciting for the students. Matt describes them as a "Price is Right" type experience where each student is called down to receive their medal. "That's really cool because their teams are cheering and everyone's looking around like, 'How many did they get?""

The students are all trying to add up the points in their heads to predict what team is going to win ahead of the announcement. The anticipation is a lot of the fun. "They do enjoy that."

Barbara in Appendix H was specifically looking for something fun for students to do to enhance their interest in science. She thought it would be fun if the students could do something competitive in science. "I was trying to find something that the kids could do that wasn't just sports because we're a small school." Kelly's first experience (Appendix J) in Science Olympiad was at a regional tournament. At it, her team qualified for the state competition. "It really hooked me onto it because the kids were so excited about it." Sophia says that her students like the competition. Leslie in Appendix L knows that students are enjoying themselves because, "I can just tell with how productive they are." She talks about how students in one of the build events would build and test their device repeatedly. "I mean they were just so excited about it."

Even when a student has not succeeded, there is still a lot of fun happening. Matt uses the Wright Stuff event to give an example of how a student can spend a lot of time and effort building a plane only to have it go down after two seconds in the air. He says they are never down or feeling worthless about that. They laugh. He hears them say things like, "Ah hahaha. That's so funny. Oh, I can't believe that happened." Matt says, "Even if you mess up, it's still fun, which is OK."

In addition to the fun of competing, students seem to enjoy the opportunity to travel. Laura (Appendix K) sees the opportunity to travel to tournaments as a benefit to the students. "When I started -- that was first in 2005 -- I said we need to get these kids to some kind of competition." She then began looking for invitational tournaments which were not common near her location. Travel may take students to places they might not otherwise see. Nationals may
take students to a state halfway across the country. For some team members this may be an experience their parents would not be able to afford personally. Laura related how important and educational trips to Washington, DC and Florida were to her students. Robert in Appendix O previously mentioned how his team had visited Cornell University and Niagara Falls. Even travelling to the state tournament may take students to a part of their state they have not seen.

As previously mentioned, Robert feels that the invitational tournaments are important for the team to develop camaraderie and have fun together. He says that traveling together on the long bus rides, being in the hotel, and eating together are all team socializing activities that the students look forward to and consider fun.

Barbara (Appendix H) likes the opportunity for her small-town kids to travel to larger schools and colleges so they can see college campuses and classrooms. "They would see more things in a science classroom than I have." The students get to see things such as animals, fossils, or skeletons that she does not have. She knows they are excited about that by their comments of "Did you see that in there?" They also get to use equipment they would not otherwise have an opportunity to experience. She mentions an event where her chemistry students came back saying, "Hey, they had us using this piece of equipment. I had no idea what it was, but I think we figured it out." She thinks just the exposure to equipment beyond her school's simple microscopes is important for the student.

Laura (Appendix K ) thinks that winning state and progressing to nationals is a special benefit to the students who can do that. She took her team three years in a row from 2007-2009. "It's a wonderful experience and it's great for the kids." However, in 2010 she says that the students just thought it was a given that they were going to national competition and they did not put in the work needed. It was not until 2014 that her team was able to make it back to the
national tournament and that was the last time they went. "We had enough participation for our State to have two teams go to Nationals but let me tell you the prep is one thing," says Laura. As stated previously her main goal was to have her team prepared enough to not come in last. She says she told her team, "There's a lot of competition here. Let's just have a good time." The team did get some recognition at the national level. "We got a first in the Bridge module at Florida and we got the Spirit Award when we were in DC." Regardless of how they place and whether they are at nationals or an invitational, Laura expects her students to show good sportsmanship. When they go to tournaments, Laura expects the team to clap for everyone. She tells them that they know how tough they worked. "They put in a lot of work, and they deserve to be acknowledged."

## Increased opportunities for invitational meets would be beneficial.

Invitational meets (or tournaments) are practice competitions hosted by schools where they invite other schools to come practice with them. These are run very similarly to the official regional and state tournaments and offer prizes for the winning teams. The sports analogy would be a scrimmage, but teams take these competitions rather seriously so the atmosphere of practice is not really present. Scott is passionate about giving students as much opportunity as possible to compete and excel. In Appendix $Q$ he explained in detail how he and a friend lobbied for ten years for changes in his state that allow individual event winners at a regional tournament to progress to state even if their team did not place high enough to advance to state. These changes were recently implemented. "... we lobbied [the] state for probably 10 years to do that because we said, 'It's so unfair that these kids win regionals, they've proven they're the best, and they don't get to go to state'."

Sandra (Appendix P) says that her state did not have any invitationals when she was a student. When schools began holding invitationals, she saw a huge difference in the level of
competition. When she was coaching middle school, she says they went to one invitational, but when she was coaching high school, they did at least two invitationals and they had to travel for those. "That made a huge difference between my two experiences. It kind of tightened the competition level as well. Just helped the students get more practice or at least more comfortable with the competition." The unfortunate thing she sees is that the invitationals are mostly held in one large city that with its suburbs straddles the state line and is quite a distance to travel for most of the schools in her state. She says that there may be five to ten invitationals a year held by schools in this city and its suburbs. Due to these numerous opportunities for competition, Sandra says that the schools local to that area "have really taken off and blown everybody else out of the water because they get all that practice in." As a state director Sandra noted that the schools that attend more invitationals and get more practice tend to win. "Definitely what I've learned over the years: doing the invitational tournaments -getting those practices. And that makes a huge difference."

Leslie (Appendix L) agrees, "I think more meets would be better. I think the kids would actually be better engaged if they could compete more often." There are not many schools in her part of the state competing in Science Olympiad. She only has one invitational that is somewhat close. That competition does not occur until December, and she says that it is hard to keep the students engaged and focused through September and October. It is hard to motivate them to put work in more than a month ahead of a competition. She says she knows the logistics of it and that her State Director does not have the volunteers to do more invitationals.

Before Covid-19, Robert's school (Appendix O) competed in 8-10 invitationals each year and would travel as far as two states away for some of them. "By competing in these
invitationals in other states, we're getting a broader, more competitive environment to teach our kids just how hard you have to work in order to win one of these things."

Scott (Appendix Q) uses invitationals to encourage the newer members who may be doubting their abilities to stay involved. He tells them, "So, it benefits you to stay in and do this because you may or may not be on the top team, but you're going to regionals anyway." He explains that the repeating State champion schools in both his state and a neighboring state mostly have their top team membership established by January or February. This is used to exclude all but the top 15 from participating in anything other than an invitational during most of the spring semester. Changes in his state SO rules mean that now the regional competition allows schools to enter up to two teams and individuals in excess of the 15 -member team can advance to State if they win. "So, you have those kids that may not make the top team but are still good in their events. And now if they win their event at regionals, they can move on to the State competition."

## Competitions encourage and teach goal setting.

Matt (Appendix N ) says he thinks Science Olympiad is a good way to get young people interested in science. He finds the competition compelling. "When I was a young person, I don't remember there being competitions for science and I thought that if I were a student, I would absolutely love something like this." Making it a competition means students must set goals and then try to achieve those goals. Of course, there would not be a need for a team without the competition. Matt has already discussed how he enjoys the competition personally and how important he feels goal setting is for students. Achieving those goals of doing well in a competition is hard work. He likes seeing the students gain confidence and achieve their goals. "This makes me feel even better if I had a small part in that." Discussion of how he sees students working hard and setting goals can be found in the next section about student benefits.

Matt sees Science Olympiad as a place where students can develop numerous skills. The first one he talks about is goal setting. "I think having a goal of any type and then working toward pursuing that goal is huge." He believes it is character building and motivating for the student. He ties goal setting and motivation together. "I think it creates a little bit of intrinsic motivation." He defines intrinsic motivation as internalized motivation where achieving the goal is the single reward. He thinks that when a student says, "'I have set a goal and I have achieved that goal.' It's a major thing for a young person to do." He believes this ability to set goals and be motivated to achieve them is very important. "It's a life skill that really would propel anybody to accomplish just about anything."

Laura says in Appendix $K$ that in the group of students that went to nationals three times, she had a group of seven that had started in $6^{\text {th }}$ grade. Of those seven, there were four girls that set going to the national tournament as their goal. "Let me tell you they ramrodded everybody." She says that she and the other coaches only had to present the event material to the students and give them incentives. The students did everything else.

Despite the problems with Leslie's team size in Appendix L preventing them from being strong contenders for overall team placing, the individual students do have a team they always want to beat. Leslie does not name the rival team, but she says that they always have that one team. "That's their main goal. So, the competitive competitors in us, we want to get them one time."

## Competition is a motivating factor.

When asked about the effects of the competition on the students, most coaches do view it as a motivating factor. Taking students to competitions can motivate them to stay involved. Scott says in Appendix $Q$ that they can get a lot of $6^{\text {th }}$ graders interested in Science Olympiad, but they must keep them involved so they stay part of the team. He tells them, "You're not quite
on the top team this year, but you're still going to regional to give you that experience." He says, "That has lit the fire in their eyes so to speak."

A positive benefit for students that Sophia sees in Appendix R is that "for the most part, everybody at some point during the year medals and it's just so encouraging." She explains how even if the team ranks in the bottom half of the pack, but one student wins an individual medal, it gives the whole team hope. It helps to keep the team motivated because students say, "Oh, we can do one more next time."

Anne (Appendix G) thinks it's sometimes better when they do not win because that can be motivating to the students to try to learn more and work harder. Leslie (Appendix L) also sees that competitive nature being a big motivator for some of her students. She mentions that her Boom-a-lever team is very motivated by competition. She has another student who is the lead in the Right Stuff event. "He's very mathematical. He'll come in before the season even begins and show me his plan." She says he always tells her, "I did the math behind it." She contrasts that by saying she has other students that do not really put the M in STEM. "They're gonna go out there and they're gonna build it and they're all trial and error." She implies that they are still very competitive in nature just with a different approach.

Scott talks in Appendix Q about the length of time between the start of school and the first invitational in November or December. He found it hard to keep the students focused or motivated to keep preparing for competition during that length of time. To build enthusiasm and maintain interest in the fall before the first tournament, Scott likes to hold mini competitions in place of some of the practices. It was originally an idea of an assistant coach's idea and Scott had done it for years. The coaches pick one event for the practice. Scott has everyone participate even if they are not planning to enter that event. "The kids love that." He says that it
is hard to squeeze it into the time constraints. "A typical event at regional [competitions] takes 50 minutes. So, we have barely enough time by the time buses are called, the kids are situated, and they've got their chrome books out and logged in." He says that they need to remind the students earlier in the week which event it is so the students can be ready. He also must have things ready for the students to jump right into it. For example, he uses the event Keep up the Heat where the student needs to use heated water as part of the test, so he will have the water ready to go ahead of time. He says that doing different events each week can keep interest going and give students a chance to try events. It also provides early competition practice for the students who are most likely to enter each of those events.

Scott says he sees the students develop self-awareness and efficiency. "You have to be efficient or you're not going to do well." He tells the students that they cannot expect to build something the night before and have it do well in competition. It teaches them that they must be prepared. Another part of a student being competitive is having the ability to choose good partners. Scott says that if a student chooses a good partner, then they do not have to work as hard because the work is going to be evenly distributed and they will generally do better as a team.

## Competitive pressure and coping with defeat.

Sometimes Leslie (Appendix L) says she sees the negative side of competition with a student. "... I don't know what their expectation is but if they don't finish in the top five, they don't want to go back and do the event again next time." Typically, she says they come back, but it depends on the student's personality. Her approach that she tells them is:

It's a learning experience and you'll get better every time and, you know, we may never beat some of those bigger schools, but as long as you're improving, it's an asset to our team. You're doing fine.

She says that most of her students have a laid-back personality about the competition. They learn from their mistakes and try to improve each time. Since they do not have a full team, she does not see them worrying about letting the whole team down if they do not do well. "They just want to be the one that shines to make sure, you know, that they're doing their best."
"Sure, there's that. That goes on." Mark in Appendix M says in response to the idea that not doing well in a competition can be stressful on the student. "I'm not going to push them real hard." He says that the desire must be innate in them. "And winnings a lot but winning is more to some kids than others." When he sees a student disheartened, he gets with the student to evaluate the situation. He asks the student, "What part of the test did you not do well in?" He does not tell the students what he thinks they did. He says, "I try to get the kids to evaluate themselves and then report back a little bit of what they did or didn't do and then how did you fix it?" He thinks this process is important because "it is just a real-life thing, you know," and his role is to guide the students to that. "Sometimes it works and sometimes it doesn't. Sometimes kids get very frustrated, don't do as well and some kids dig their heels in and go." He says that those who find other things more interesting will start doing those other things and they will be done with Science Olympiad. The students who see Science Olympiad as contributing to future goals keep working and researching their events. "They eventually get to the point where they feel confident. It becomes them."

Sandra (Appendix P) comments, "I think you have a few teams who have won and have come to expect that they'll win. And then you may have a few students and other teams that are that way, too." When asked if that is a drawback or not, she says, "Well it definitely raises the level of competitiveness and level of competition which, for the teams that go to National, that's needed." She describes how in some other states the most competitive teams are from schools
that are science and math focused. "You know that this is what they learn all day is doing this stuff. For our students to be able to compete against them, they must be focused on winning if they want to win." She continues, "I mean, there are definitely drawbacks because [competing] puts a lot of stress on themselves. It also puts a lot of stress on their teammates if their teammates are not as up there as they are. It also puts stress on teachers and parents," says Sandra. "So, teachers who just have to deal with this student that's overly stressed stresses out the teacher, too." She has already discussed the example of how she had to deal with the overly competitive student who was picky about his partners because he did not want them to pull him down. Going back to her own competing days, Sandra tells a story about an event where she was the one pulling down the score. "I was the lower level, but we both went into that expecting it, so it was fine." She laughs, "I didn't feel bad, and he didn't get too upset with me, so it was OK." She does not think she has specifically seen or heard anybody tell her about a specific instance where a student has felt inadequate because of not doing well at Science Olympiad competition.

On the individual level Scott in Appendix Q has seen some kids not do well at the competition and not want to continue because they said they did not enjoy it. Other students come back with the desire to improve. Scott sees kids leave the team because they just did not enjoy going to events. He says that sometimes the coach just must pick them up and boost their ego a little. Sometimes all it takes is for him or another coach to look at what they did and say, "Well, you got this section right, so you're not that far off from doing well."
"One of the best and brightest kids we had as a sixth grader was in the gifted program," says Scott. "His parents' expectations were so high that he had to win." Scott describes how after taking second place to the same team at two different tournaments, he was struggling with
the situation. "I think that was probably one of the best things that could have happened to him. It took his partner in the event to tell him that it wasn't that they weren't good enough, it was just that the other team knew the material a little better and that they could either get better or not." In the end, Scott says they placed at State in their event which he thought was a huge accomplishment.
"It's a competition. It is what it is." Laura says in Appendix K that some students take it hard when they do not place at a competition. She explains that she has had instances in the past where everyone on the team has won a medal except for one student. Like Mark, she handles these situations by talking with the student and asking them, "Did you do as much as you could do?" She says that if they say they have, then that is okay. "It's not everybody can win. This isn't about winning." Then she will ask them if they have learned something. "That's why we are doing this. We're not doing it for the medals." She admits the medals are great and make the students feel good, but when she sees a student sad and dejected and wanting to quit because they did not win, she tells them, "Well, okay, you can do that, or you could study harder." She has an example from the current year where she asked a girl, "Well, okay, did you do everything you needed to do or were you fooling around some of those times when you were meeting?" The girl admitted, "I was fooling around." Laura told her, "There you go. Maybe you need to rethink this, but it's up to you." She says most students decide to dig in and work harder.

Anne (Appendix G) does not see that there is pressure to win with her team, but she says that if it did happen, she would consider that a personal drawback as well as a drawback for the students. "You want it to be a place where kids can go and safely make mistakes and learn from there." She does not want her students to feel they have to go find a professional engineer to help them build a catapult to win. "It's not the learning experience they should have, and we
don't want to be in that position of 'Well, that's the only way we could be competitive'." She says her school understands that. "They know we want to keep this kid friendly, and kid focused."

Leslie indicates in Appendix L that their lack of numbers puts them in a situation where they are not able to compete as a team. "We don't enter all the events. So, I just let kids enter what they're interested in." This automatically puts them down point wise in the team competition, so she just tells them, "You're just competing against yourself".

During the pandemic restrictions, the main issue students had with Science Olympiad was the virtual format. "It's really hard to get kids enthusiastic about logging onto a computer and taking a paper test when they're used to doing some things hands-on." Kelly (Appendix J) says the students disliked not being able to leave the school or their home to do Science Olympiad competition. Part of this was because the students felt that sometimes the other schools weren't being completely honest when testing online. Kelly says this is "because it was really easy for a kid to have his phone right next to him and be able to look up an answer or something." She said she was a real stickler for the rules, but when the students got their results back and they had performed very poorly compared to other schools it made them feel like other schools were not following the rules as strictly.

## Competing in other science competitions.

Several coaches believe in the benefit of competitions enough that they sponsor students to enter in competitions in addition to Science Olympiad. Leslie mentions in Appendix L that her team also enters other STEM competitions. These are mostly competitions she finds that businesses in her area sponsor and they may vary in type from year to year. Sophia's team (Appendix P ) is a general science team and also competes in other science-related competitions such as Science Bowl and Prometheus Bowl.

Mark says in Appendix M that he does robotics for the first nine weeks of the year and then switches into Science Olympiad. Mostly the same students are on both teams. He explains that he has a history of competing with the students who will become his high school Science Olympiad students beginning in middle school because there he takes his middle school students to Technology Student Association competitions. His teams in those competitions have competed at both state and national levels. He has done that for about 14 years. So, it is natural for them to take that experience on into Science Olympiad with him in high school. "They knew the time commitment and they knew what I expected out of them and what they expected for me, and it just worked for the last four or five years. So, we just kind of kept kids going." Mark says, "I've had a few kids that have had a lot of issues because they kind of thought that they needed to work or had to work," says Mark. "So, that kind of cut into some things and then, of course, the kids out for sports. Those are the ones that, you know, do sports, and come in once a week and then towards the end they skip two or three practices that week to kind of wrap things up. But that's up to the kids."

## Challenges students face as a part of participation in SO competitions.

Overcoming procrastination is a challenge for many students. Leslie (Appendix L) says she would like to get her students to not wait until the last minute before a tournament to do their work. She says the students will suddenly think, "Oh it's the week before the competition, we really need to buckle down." She wishes they would realize that they need to be doing it for that whole time before. "That gets a little hard sometimes - to let them know that the practice isn't just the practice. It's where you're going to succeed in the competition later."
"I can't get them to realize they aren't using their time wisely." Barbara comments in Appendix H about her younger students who like to sit and talk or be on their phones. She says that the older students are better at time management than younger ones. She thinks that maybe
the older students have learned how much time it takes and they know they have only so much time. Some of this could be because the younger ones don't know how to start compiling their notebooks without some mentoring. "I can't get them to understand that they've got to come to practice now and not a week before we are ready to go." She says that sometimes she has a hard time getting them to prepare for the testing events. "Nobody wants to do the notes and take the tests. They just want to build."

Laura (Appendix K) sees a need to keep students from overextending to avoid burnout. "Oh, I've had kids want to do six and I tell them, 'Nope. Absolutely not."" Laura says this in response to a question about four events causing student burnout. "I've had some really smart kids take five sessions and they've done it, but they're real tired at the end of the day. I really want them to pick four and put the work in on those." She says it is also a large time requirement for the students to prepare for that many events properly. "If they put an hour in every night in addition to homework, that's a lot of time. But, if you want to go to Nationals, that's what it's gonna take."

Coaches do not feel that students have very many negative experiences related to Science Olympiad. As seen in examples previously given, most coaches discuss how they will talk to a student that has not had a good experience at a tournament and they will try to help turn that experience into a positive learning opportunity for the student to improve for the next time. Occasionally, a student just does not enjoy the process. This lack of enjoyment is not necessarily related to a bad experience by the student. It may just be a lack of enthusiasm for the whole process. Scott sees kids leave the team because they just did not enjoy going to events.

A student who has been on the team all year or for several years prior has probably enjoyed the activity in the past and now there is another issue that needs to be addressed if they
suddenly want to quit. Beth (Appendix I) mentions that sometimes her juniors or seniors that were previously on the team had to leave due to time conflicts. "The burn out," says Sandra in (Appendix P). "Gosh! There're so many factors that can contribute to the burnout, um, just so many things that students deal with." She describes some of what she noticed when she was a high school coach. "Some of the students who had gone for so many years, they just got so tired from the other pressures in high school that they quit Science Olympiad." She says there is the competition pressure of "I gotta do well in this event so I medal, but then there's also the pressure of we don't want to completely flake out because you're going to affect the whole team." So, she says that students can get stressed on the day of the tournament and get tournament burnout, but she sees other things being more responsible for burnout. "High school kids that have jobs, maybe other family pressures, other after-school programs they're involved in, homework - all that working together." She says that just trying to stay afloat in all of that is enough to cause burnout.

Several coaches mentioned the need to be able to read students and know when they need some extra encouragement. Scott (Appendix Q) says that if they are disappointed in how they did at a tournament, sometimes the coach just picks them up and boosts their ego a little. Sometimes all it takes is for him or another coach to look at what they did and say, "Well, you got this section right, so you're not that far off from doing well." Laura says in Appendix K that when she sees a student sad and dejected and wanting to quit because they did not win, she tells them, "Well, okay, you can do that, or you could study harder." She says most students decide to dig in and work harder. She has an example from the current year where she asked a girl, "Well, okay, did you do everything you needed to do or were you fooling around some of those
times when you were meeting?" The girl admitted, "I was fooling around." Laura told her, "There you go. Maybe you need to rethink this, but it's up to you."

In several of these cases where the students wanted to quit and simple encouragement was not the issue with the student, coaches indicated that they did not try to persuade the student to stay on the team. There is an understanding from the coaches' perspective that Science Olympiad is not for every student. One exception to this is Laura. She says that when students who have been on the team for a year or more suddenly want to quit, she asks them, "What's going on? You know, why are you backing out?" She says some of them will say, "Oh, I really didn't like it." She tells them, "Well, it's too bad. We invested a year in you. This is, you know, too bad. Unless somebody else comes along that's better, you know, you're gonna be in it." This, however, is somewhat of a different situation than the new student going to a tournament or two and then deciding that they are not interested.

Barbara indicates in Appendix H that one of the things that she thinks decreases the number of students who leave the team is how she recruits. "I don't' beg. I don't plead." She admits that if there is a student who she thinks would be good at Science Olympiad, she might say, "Hey, why don't you try?" She says that she has found in the past that if she has to beg a student, then it is not something they really wanted to do and they end up quitting.

The fact that Science Olympiad does not appeal to everyone is not considered a negative by most of the coaches in this study. In fact, it is mentioned as one of the things coaches feel makes Science Olympiad attractive to students. Because it appeals to students with certain interests and mindsets, coaches see that Science Olympiad is a place where these students find other like-minded people.

## Sub-question 1B

What experiences do coaches relate as personally applicable about their work in Science Olympiad?

The themes that emerged for sub-question two are listed in Figure 4.2 and are discussed individually in the following sections.

Figure 4.2. Themes Related to Research Question 1 Sub-question 1B

| Mentoring relationships |
| :--- |
| Sharing in student success |
| The role and nature of stipends from the perspective of coaches. |
| Learning new subject material. |

During the interview coaches mostly directed questions about their personal experiences back to discussing student benefits or in giving advice on how a new coach or a coach in a poorly funded situation can overcome obstacles to having a Science Olympiad team. As Scott said in Appendix Q when relating an instance when a reporter tried to focus on the coaches’ efforts in hosting a tournament, "That's not why we do this. We do this meet for the kids. Please focus on that."

Most coaches have stories of individual students who found success in Science Olympiad. Some of these stories have been related previously in the student benefits discussion. Some of these feature students who were underdogs academically finding that they were capable in one or more areas of STEM or students who thought that STEM subjects were beyond them
finding an area in which they had a knack and could excel. The coaches' enthusiasm in sharing these stories and the joy in their voices shows that these experiences are treasured by them.

## Mentoring relationships and sharing in student success.

Several coaches discussed being able to build a better mentoring relationship with students. Getting to know the students outside of a classroom setting gave them a different perspective on some students and allowed them to be better guides to those students. Anne (Appendix G) thinks it is good for the students to see her in a different context from the classroom. "I think we suddenly become less intimidating." She thinks it allows a teacher to be better able to help guide the students through their high school career and that is a benefit to the student to have that guide. "I think a lot of kids realize you can be an ear for them."

Friendships with students are also an enduring aspect of Anne's Science Olympiad experience. She thinks the outside of class setting is beneficial. "It's just such a nice thing because you get to know kids in such a different capacity outside the classroom." Anne stays in touch with many of the students she has taught. "I've mentored a few of them in their first year of teaching. That's really been amazing." Some of her former students come back to help run events at the school invitational. She says she and her former teammates would often come back to do that too when they were in grad school. "For me, it's just a lot of like shared community warmth and this is that thing I contribute because it's that thing I know how to do."

Barbara also talks in Appendix H about having better relationships with her Science Olympiad students as a personal benefit, but she also discusses how it can be a drawback in the classroom. She says that sometimes in class her Science Olympiad students might get a little carried away with joking or talking and she must reel them in. "Okay, this isn't Science Olympiad, you know, this is my classroom." She says that it does not go unnoticed that there is a difference by the non-Science Olympiad students. Sometimes the other students will throw it
back on her that they think there is some preferential treatment. "Well, he's a Science Olympiad student. They're going to get to do something we don't."

Kelly (Appendix J) says, "You really get to know the students and the students get to know you." She feels this is of the most benefit when you also have the student in an academic class. When asked if a teacher develops that relationship during the class anyway, she responds that the Science Olympiad relationship is deeper. "Seeing them after school and participating in a program and getting to congratulate them and be there for them and stuff like that - it's just deeper." To explain the differences, she says that once a student who has only had her in class leaves her classroom, they are done with the class and with her. Students she has coached in Science Olympiad are continuously coming to her room to just be there. If she is currently coaching and teaching the students, they feel comfortable coming to ask her questions about things in class as well as things outside of what may be in class. Kelly only teaches sophomore level students and not all sophomores are required to take any of the classes she teaches. Therefore, there are some students that she never gets to meet and teach in one of her classes. However, some of these students do join the Science Olympiad team and she gets to know them through this activity. She thinks the greatest benefit to the student is for them to be on the Science Olympiad team first and then have her as their teacher later. "We just seem to have a better relationship and understanding."

Robert says in Appendix O that the social interaction with the students in Science Olympiad helps in the classroom. He notices that if he has taught a student as a freshman or sophomore and then has them again as a junior or senior, the students feel like they have that relationship with him. "It's even stronger with the ones that participate in Science Olympiad." He says that those students are not quite as afraid of him, and it helps. "If you have a two-way
conversation with the students, it really facilitates the learning in the discussions and things like that they're not afraid to ask questions."
"But at the end of the day," Matt sums up his view of coaching in Appendix N, "it's really just relationships with young people." He likes the personal relationship with the students. "The reward of seeing them succeed is really probably the biggest benefit." When he sees his students succeed, it makes him feel like he contributed something to science. "I'm passionate about science and science education. And, so, this kind of fulfills that kind of goal."

The reward that seems to keep most of these coaches going is sharing in the student successes. The obvious occurrence of this is when students place at a competition. However, most coaches who discussed this gave examples that did not include competition outcome. They looked for student success in things like greater self-confidence or self-esteem in students that had previously exhibited a lack. Of course, having students place even at the lowest ranking to get a medal when that student had not previously thought they could do it is a shared success the coach feels. As mentioned before, Scott in Appendix Q calls winning or placing in the top three "icing".

The things that make Barbara (Appendix H) want to keep doing Science Olympiad every year is the opportunity to witness student success. Barbara talks about the excitement when two girls on her team won their category at state. "We were so excited that we could do something like that." She says she just enjoys watching students do things they didn't think they could do and to just compete even if they only do okay in it. "It's rewarding in itself." After describing this she pauses and says, "I can't talk because I am tearing up over here."

Matt (Appendix N) says he loves seeing students have an "A ha! phenomenon". He loves seeing students acquire new knowledge and work hard. "My main reward I get is being involved
in that process for young people." He enjoys supporting them and cheering them on. He also enjoys being with young people and seeing them grow and change and develop their full potential. "It's part of the reason I became a teacher." He likes seeing the students gain confidence and achieve their goals. "This makes me feel even better if I had a small part in that."

Scott says that seeing their excitement when they do well at meets is evidence for him that they are enjoying the experience, "Seeing them run down the stairs and not trip while they run to get their medals at meets (laughs). Um, and then texting their parents and taking a picture right away." Scott also likes being a part of other coaches' successes.

## Friendships with other coaches.

Scott explains the history of his mentorship of other coaches. He says that there were several coaches that helped him get started. "I owe those coaches tremendously." One of those coaches jokingly told him once, "All you did was beat us, you know. If we'd have known that we wouldn't have helped you." And in his turn, Scott became a mentor to other coaches. He says that there are other academic competition programs, but as far as he knows, Science Olympiad is the only one that goes the whole school year. Often new schools do not understand this and do not know about the invitationals. So, they will just practice two weeks before the regional tournaments and then they are done. He said that he was in his third year of coaching before he realized the importance of invitationals. He and some of the other coaches try to partner with some of the new schools. He tells them, "If you really want to be successful, lean on us. We've got the experience. We'll share tests with you." He says all the teams do a lot of sharing of old tests and it helps expand the program for new schools when they are able to take advantage of that.

He says that he has developed some really close friendships with other Science Olympiad coaches. "Some of my closest friends in the field of Science come about due to Science Olympiad and I not only consider them peers and coaches I've learned from, but I consider them friends." He says that he has seen some of the other coaches over the years on a regular basis outside of school and outside of Science Olympiad and some of them he only sees at tournaments. A change in tournament structure in recent years has been the addition of a lunch break into the schedule. "A nice benefit from this is that I have been able to sit down and eat lunch and have more in-depth, more personal conversations with some of those coaches." Scott explains that tournaments often run nonstop from $8: 30$ in the morning to $1: 30$ or 2:00 in the afternoon, however in the last couple of years, some of the schools have started putting a break in. "And the guise for doing that is for the kids so that the kids can actually find time to eat under a semi normal situation so they're not stressed about when they can go eat lunch." For him that has provided a nice side benefit. "I have been able to sit down and eat lunch and have more in-depth, more personal conversations with some of those coaches." Even if tournaments are the only interaction time he has with the other coaches, he thinks they all benefit and feel it is important. "We cherish that time. We're - I don't want to call us a unique set because there are other programs that do this too, but we're - we're a unique set."

Anne also talks in Appendix G about the friendships and fun. As mentioned previously, the friendships started for her in high school with her teammates. As a coach she says her friendships have gone beyond what they were as a student. Because she teaches at a private school and is not part of a district, Science Olympiad is the way she gets to meet the other science teachers in her city. She says they see each other at tournaments and exchange
information, phone numbers, ideas, and exchange strategies. "I feel like I've made some really cool friends just as a coach."

Anne is in the same state as Scott and that state has a tradition of coaches helping each other. She explains that this may be due to her state being one of the first states to get on board with Science Olympiad. To get the program going, the first schools had to recruit other schools so there would be enough schools to have tournaments. "There were a few coaches locally who went out and recruited other schools to come into the fold." She says that they held workshops and mentored new teachers. The state has lost teams in the past few years and the new state director is trying to revitalize the state by trying to connect new coaches with more experienced ones so that the new coaches feel supported. "Sure, we have some rivals, but they're pretty friendly rivalries." She says her team gets beat frequently by their main rival across the state from them, but she and their head coach exchange thoughts and practice tests back and forth. She admits that rivalries used to be less fierce when the state could send two teams to Nationals.

Anne sees that rivalries also seem to fade when coaches have opportunity to talk out issues with each other and share strategies. When she does this, she begins to feel a small stake in the other coach's team. Anne uses as an example the situation between her and her main rival coach. "When we come in first and the other ones come in second, we actually feel bad because it's like looking at our own kids not getting to go." She sees this with other coaches as well and thinks there is a lot of empathy and respect in her state system. "I'd like to think we all get along pretty well."

Barbara (Appendix H) is also in the same state as Anne and Scott and says that she did not really understand what she was doing when she started. "It was really confusing to read all those rules and all. I didn't understand how difficult some of it was." When she found other
coaches she could talk to about Science Olympiad, it became easier for her. Scott was one of those coaches.

When asked about the importance of interacting with coaches from other schools, Beth (Appendix I) says, "It's really important. It helps a lot to just have people to talk to, but more than anything coordinating for regional is just I have to talk to the rest of the (especially the high school) coaches." She continues, "We have another middle school that coordinates the middle school part of the regional but then I end up talking to them a lot too because they're all coming to our high school." She says that there is a web page used by her state and a neighboring state that the coaches use to coordinate what is going on. She does not indicate that there is much social interaction or exchange of ideas going on there. "We have one meeting in October where we get together and Sandra (the State A Director) talks about the new things for the year and what the plans are and things like that. But it's hard to get the high school coaches together." Beth says that when she was coaching at the high school her communication with other coaches was only when putting together the invitational tournament and just communicating with the coaches about getting them to invitational tournament. Otherwise, there was not much communication about anything else. "I feel like now there is more talking between coaches across schools and I think that's great as long as they think it's great too." She laughs.

Most of the other teams in Leslie's state are an hour or more away and so are all the competitions. In Appendix L she says it is to the point that the principal who hired her to coach Science Olympiad asked her, "Can't you find competitions around here? Isn't there something closer that the kids can participate in more often?" Leslie wishes she did not feel so isolated. She says, "It would be nice if there were more schools around here involved that we could even collaborate on non-competition days with those other coaches or other teams."

Other coaches do not feel the need to interact with coaches from the other schools. Matt (Appendix N) says, "I know of no other coach. I know the teams. I know the names of the teams." He describes a summer event where all the coaches would go and talk about all the different events. The event sponsors would go through their events and explain them. "And, so, we got to kind of pal around a little bit with other coaches, but I don't think that was the - that wasn't the goal of those events. It wasn't to become friends with other head coaches." Matt does not see it as a desirable thing to become friends with the other coaches. "It's like we're competing against these people." He draws a sports analogy, "You're not going to put like head coaches of football teams together in a room and discuss your strategies on how you're going to win. Probably not going to happen."

Matt was also uncertain about social media platforms for the coaches in his state. "I know that my team has an Instagram so if other teams wanted to follow us, they could, but, uh, as far as I know no other teams follow us. I don't follow any other teams." He comments that upon thinking about that it might not be a bad idea to follow the other teams. "Maybe I should get a head up on the competition. Maybe I should do that."

Mark (Appendix M) says he does not communicate much with other coaches in his region or state. "There's a few around the area that I talk to a little bit." He says that if he is going to do an event at a competition, then he might ask one of the coaches that has done that event before for advice on how they ran the event. He says that some of the other coaches have put information on the internet to answer those questions so he will just go there. His state does have a Facebook page and there has been some information on it, but he thinks that the national page is as informative if not more.

Sandra in Appendix P also did not experience much interaction with coaches from other schools while she was coaching. However, she feels the interaction is a positive thing for coaches and is working to encourage it. "I feel like now there is more talking between coaches across schools and I think that's great as long as they think it's great too." As State director, she has a Facebook group for the coaches in her state. "I'd say about half the coaches are on there. It is an easy way for me to share stuff with the coaches and then for the coaches to talk with each other on there." She mentions that two topics of discussion have been the discrepancy between the stipends received at different schools and questions about accommodations for students that need special accommodations. "So, I have that for my coaches and then the state directors also have a Facebook group and we do the same thing on that Facebook group.

## The role and nature of stipends from the perspective of coaches.

Sandra stated in Appendix P that the stipend had been an incentive at one time for her due to needing to supplement her salary. She also indicated that she might have done it without the stipend. "When I was coaching at the high school that was necessary just because the Catholic Diocese, [has a] starting pay . . .much less than public schools. So, I signed up to sponsor anything I could to get the additional stipend," says Sandra laughing. Sandra explains that the stipend was separate from the Science Olympiad budget. The stipend was specifically to go towards her salary and then she had a separate Science Olympiad budget to pay for all the equipment and resources. "That was one of the few things that I didn't have to use my pocket money for," she said. "In my classroom I still had to do that a lot, but not for Science Olympiad." Referring to the coaches' discussions on social media she says, "I know the coaches in the state have been talking about that because it varies from school to school. The consensus is if the school pays a stipend, it's the same as being a sponsor of a club not a coach's stipend."

Scott (Appendix Q) receives a stipend, but he does not consider it a major benefit. "I will openly admit that we are the most underpaid Science Olympiad coaches in the region." He bases this on his communications with the many coaches with whom he has built relationships over the years and gives a specific example. "The other coach that is with me now, she made twice what she makes now when she was at her other school." That other school is part of a large school district in the state. "In that region the Science Olympiad coaches are paid correspondingly like sports coaches." Scott says he gets $\$ 650$ for the whole year. "That's enough to buy a whole load of building supplies and supplies for events, so we've always done that." In other words, he does not even keep the stipend to compensate for his extra time. "Luckily, my family is in a situation where we're financially sound. Every bit of money that I made as a stipend went right back into the program."

Mark in Appendix M receives a stipend from his school which he says he gets to keep for himself and does not have to spend for the team. Leslie says she gets a stipend of about $\$ 400$ per year. When asked if she gets to keep it to compensate for the extra time or if she winds up spending it to fund the program, she replies, "Well, I didn't really think of it that way. I just have a tendency to run down to the hardware store and get what they need."

Beth (Appendix I) is not a teacher at the school where she coaches, but for the past two years, she has received a stipend for her efforts. "My principal really fought for that, so it was nice of her. It had been a thing in the past, but that was when a teacher had done it." Beth says that she does not keep much of it as compensation for personal time spent coaching. "It pretty much goes back into Science Olympiad, but it doesn't feel bad anymore. I'm not like spending just our own family money. It's good." She does have a Science Olympiad budget which helps some, too.

Kelly says in Appendix $\mathbf{J}$ that her school was excited about bringing in the program, but the support was the same as it had been at the previous two schools and did not include a stipend. It was not until after she had been there a couple of years that they offered to pay her a stipend. She says that she gets $\$ 1650$ per year. Then two years ago she asked them to give her a class for Science Olympiad and they did. "I think that meant a lot to me that they were willing to build in this class and let me have the class."

Last year was the first year that Robert (Appendix O) has received a stipend. "I'm the only one in the upper division that I know of that's getting it and not to put too fine a point on it, but it's minimal. He says he gets $\$ 2000$ for the whole year which is the same as a part-time assistant sports coach gets for a cumulative 200-hour season once a year. "I put in 200 hours easily a month, every month." He points out that Science Olympiad is not a seasonal activity. It runs the full school year. Though mathematically these hours seem to be an exaggeration, this statement conveys how Robert views the situation.

Matt (Appendix N) says he does get a stipend, but only because the previous coach fought for it. He said he would probably do it without a stipend because he just would not think to fight for it like that. He gets a stipend as well as a budget which is sustained with membership dues and fundraisers. So, he gets to keep his stipend as personal compensation. The budget is not large enough to handle travel expenses, but his principal has said that if they were staying in state, the school would provide a bus and a driver.

Laura in Appendix K does not receive a stipend. She says that there was an exception one of the years she took the team to the national tournament. The priest and the principal in charge that year got a thousand dollars together and gave it to her for going to nationals.

Anne (Appendix G) also does not receive a stipend. "The benefits for me are not financial," she says. Her school expects each teacher to take on extra duties and this is more interesting to her than other things. She says she would rather be doing Science Olympiad than watching study hall or "doing something that I'm less comfortable with like chaperoning a bunch of school dances or something like that".

## Learning new subject material.

Part of Kelly's (Appendix J) enjoyment in coaching Science Olympiad is that she must learn new things when she does not know something about a category. "It forces me to study a little bit and I like to learn." Science Olympiad has also given Barbara (Appendix H) motivation for some personal learning along with some of her students. She admits that she has no shop skills. "A lot of the kids taught me how to run a drill because I didn't really know how." A parent came in and taught electronics to both her and the students. She says there has been a lot of learning along with the students through the years and this has been some good personal growth for her. "It got me out of my comfort zone to learn how to do some of that stuff."

Matt says in Appendix N that coaching Science Olympiad has allowed him to feel like he has become more rounded in his scientific knowledge. His background is mostly in Biology and a little Chemistry. The varied topics covered by 23 events expose him to other fields of science. "The Astronomy events are really cool because I get to hear and see and read what they're doing and that kind of opens me up a little bit to be exposed to a little bit more science." He says it helps give him new examples to use in class. He explains that he pulled Jupiter from Astronomy into Chemistry as an example. The discussion was about gases and pressure, so he brought up Jupiter as a gas giant that is mostly composed of hydrogen.

These experiences seem to act as the source of motivation to keep the coaches going year after year. It seems that they combine to give the coaches a sense of satisfaction. Robert
(Appendix O ) is passionate in his view that education should go beyond academic concepts. He sees Science Olympiad being of greatest benefit to students because application of knowledge is a part of every event. He gets personal satisfaction out of seeing students learn how to apply knowledge.

Sophia in Appendix R does not give a lot of personal benefits for coaching Science Olympiad, but she says several times that she really enjoys working with the students. As stated previously, mentoring Science Olympiad gives Anne (Appendix G) more satisfaction than the other options would. "It's just I think you get a passion for something and it's just so fun to communicate that on - I think it's very special."

When asked again how all of this is a benefit to her, Kelly (Appendix J) responds, "Oh, it makes me feel good that they love science!" So, for Kelly it really comes back to the students and getting them excited about science. She says that is very satisfying for her and it's fun. "If we didn't enjoy it ourselves, we wouldn't continue to do it." She says she enjoys going to the tournaments as much as the students do. She enjoys making all the plans for the team to go to invitationals. "It's like a big puzzle for me in trying to make sure everything works together."

For Scott in Appendix Q, Science Olympiad is what keeps him going in teaching. "I don't do Science Olympiad so I can teach. I teach so I can do Science Olympiad." He thinks most coaches are in it because that is where their heart is. "They want those kids to experience the 23 different events of their choosing. They want them to do that, and they want them to do well."

## Chapter Five - Discussion and Implications

## Overview of Discussion

Science competitions appeal to some teachers and not others. This study sought to increase understanding of why some coaches were drawn to sponsor a competitive team for the Science Olympiad. The method to accomplish this used naturalistic inquiry to explore the various experiences of coaches while coaching their teams. Common themes emerged between coaches from schools differing in demographics and state competitive structures.

In the course of this study, some themes emerged that were not anticipated in the research questions but gave knowledge that could be valuable to future research or applicable to current Science Olympiad coaches especially new coaches not familiar with Science Olympiad. These findings are included in their own section as well as a section compiling some of the advice coaches would give to new coaches. Conclusions are drawn from both sets of key findings and linked to the related literature. This chapter concludes with recommendations for future research.

## Discussion of Key Findings

## Key findings related to Research Question 1 Sub-Question 1.

The themes that emerged in the data analysis are in this section grouped under the three points in the Research Question 1 Sub-Question 1. Figure 5.1 shows these three points which will be headings for the key findings in this section.

Figure 5.1. The three main categories of Research Question 1 Sub-Question1A


## Science knowledge.

Science Olympiad contributes to a student's scientific knowledge and provides in-depth knowledge in specific areas of interest to the student. This is supported by the interview responses. Eight of the twelve coaches interviewed stated that Science Olympiad increased content knowledge and gave examples. The consensus is that Science Olympiad provides subject knowledge above and beyond what is taught or required for secondary education. Two of the coaches believed there was a correlation with Science Olympiad participation and state test scores. Additionally, several coaches commented that the in-depth knowledge on topics not specifically addressed in school curriculum benefitted students exploring future careers. The two common themes that emerged under Science Knowledge are shown in Figure 5.2. Table 5.1 lists which coaches commented on each of the themes.

Figure 5.2. Science Knowledge Themes


A common theme from the coaches is that Science Olympiad increases awareness of the scope of STEM showing students that STEM topics reach far beyond classroom Biology, Chemistry, Math, and Physics. Kelly says that many of her students think that science is confined to "books, papers, and maybe a lab". Robert likes that Science Olympiad exposes students to outside of classroom, practical application science. Scott sees this as important for helping students discover future careers. He says that often his students join Science Olympiad interested in a STEM career, but uncertain which field they want to pursue. Most of the coaches can give examples of Science Olympiad participants who have pursued STEM fields in college. However, the consensus is not that Science Olympiad caused them to have an interest in STEM careers, but rather that Science Olympiad helped the students to refine and confirm their specific area of interest.

Table 5.1. Coaches' Commenting on Science Knowledge Themes

|  | Content <br> Knowledge | Awareness of Science Fields <br> \& Career Options |
| :---: | :---: | :---: |
| Anne |  | $\sqrt{ }$ |
| Barbara | $\sqrt{ }$ | $\sqrt{ }$ |
| Beth | $\sqrt{ }$ | $\sqrt{ }$ |
| Kelly | $\sqrt{ }$ | $\sqrt{ }$ |
| Laura | $\sqrt{ }$ | $\sqrt{ }$ |
| Leslie |  | $\sqrt{ }$ |
| Mark | $\sqrt{ }$ | $\sqrt{ }$ |
| Matt |  | $\sqrt{ }$ |
| Robert | $\sqrt{ }$ | $\sqrt{ }$ |
| Sandra |  | $\sqrt{ }$ |
| Scott | $\sqrt{ }$ | $\sqrt{ }$ |
| Sophia | $\sqrt{ }$ |  |

## Student skills development.

In many ways it is difficult to separate skills from personal growth since accumulation of all skill types is part of personal development. Coaches mentioned that students develop skills in working with others. They also see students taking on leadership and responsibility for at least one of the events in which they compete. Goal setting, self-awareness, time management, study skills, and efficiency are other skills mentioned in the interviews. Students learn quick study strategies and how to quickly learn information which will benefit them later in life. Figure 5.3 depicts the skills themes that emerged. Table 5.2 lists each of the coaches commenting on each of the skills themes.

Figure 5.3. Skills Themes


Coaches mentioned discipline specific skills as part of the content knowledge discussion.
Most skills were only mentioned once and by different coaches. Time management and study/research skills appear to be the two most frequently mentioned by coaches. It is possible that these two skills are somewhat universal for Science Olympiad participants while other skills may be more event or situation dependent.

Table 5.2. Coaches Commenting on Skills Themes

| Coach | Time <br> Management | $\begin{array}{\|c} \hline \text { Research } \\ \text { Skills } \\ \hline \end{array}$ | Communication Skills | Tool Usage |
| :---: | :---: | :---: | :---: | :---: |
| Anne | $\checkmark$ | $\checkmark$ |  |  |
| Barbara | $\sqrt{ }$ | $\checkmark$ | $\sqrt{ }$ | $\sqrt{ }$ |
| Beth | $\checkmark$ |  |  |  |
| Kelly | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |
| Laura | $\sqrt{ }$ | $\checkmark$ |  |  |
| Leslie | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |
| Mark | $\checkmark$ |  |  |  |
| Matt | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |
| Robert | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |
| Sandra | $\checkmark$ |  |  |  |
| Scott | $\sqrt{ }$ | $\sqrt{ }$ |  |  |
| Sophia | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |

Coaches noted several specific study and/or research skills that they believed were important for students to learn and which they saw students gaining through SO participation. These skills are summarized in Figure 5.4.

Figure 5.4. Specific Study/Research Skills Mentioned by Coaches

| Finding information and taking notes over event topic |  |
| :---: | :---: |
| Strganizing notes to meet event requirements |  |
| Studying the information |  |
| Using the notes at an event to discover gaps |  |
|  |  |

## Personal growth.

As previously mentioned, it was difficult to separate skills from areas of personal growth.
To separate them, themes were considered personal growth if they were more involved with character traits or character building than the learning of how to do something which was previously categorized as a skill. Six themes emerged under this category and are shown in Figure 5.5. Each theme is then discussed.

Figure 5.5. Personal Growth Themes


Teamwork was mentioned as a skill students needed to develop. Students are benefited from having to learn to cooperate and work with others. Teamwork was also discussed in the light of camaraderie. Some coaches indicated that some of the team members are stereotypical "science nerds" and since they do not fit well into any sports teams or other school activities, they have a hard time fitting in at school. Science Olympiad gives them a place to belong and to experience what it is like to be on a team.

In his interview Mark says that students learn to deal with the stress of competitions and to get to a point where they feel confident. Scott talks about students learning to deal with life sometimes feeling unfair when rulings go against them. He also says that they learn that not
winning first does not mean you are not good enough. Several coaches mentioned that students learn to deal with different personalities on their team. Some aspects of mentorship of less experienced team members by the veteran team members is mentioned in all the interviews. The coaches credit the sense of team and the camaraderie they see develop to this practice.

Coaches stated that through being able to share activities with like-minded students, participants develop social skills. Those specifically mentioned by coaches cover a wide range. However, not all members of a team fit the idea of socially isolated "science nerds". Some "science nerds" do get involved in other school activities. Coaches mention student conflicts for practice and tournaments with practice times for sports teams as well as other team or group school activities (quiz bowl, band, choir, etc.). Since Science Olympiad can appeal to a range of students, this means that students that might not normally interact with each other wind up having to work together. Coaches comment that this teaches students how to work with people who might not necessarily be friends and teaches respect for others outside their social circle.

Students also develop patience, perseverance, dedication, and learn to take responsibility. Science Olympiad participation takes self-discipline and builds self-confidence. Students gain the confidence and skills to continue learning more on their own. Coaches comment that this increase in self-confidence leads to less test anxiety and motivation to do better in school. The coaches commenting on each of the six themes is given in Table 5.3.

Table 5.3. Coaches Commenting on Personal Growth Themes

| Coach | Teamwork | Sense of Success | Self- <br> Confidence | Fun | Self- <br> Reliance | Leadership | Coping <br> Mechanisms |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Anne | $\sqrt{ }$ | $\checkmark$ | $\sqrt{ }$ | $\checkmark$ | $\sqrt{ }$ |  | $\checkmark$ |
| Barbara | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |  | $\checkmark$ |  |
| Beth | $\checkmark$ | $\checkmark$ |  | $\checkmark$ |  |  | $\checkmark$ |
| Kelly | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |
| Laura | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\sqrt{ }$ |  |  | $\checkmark$ |
| Leslie | $\checkmark$ | $\checkmark$ | $\sqrt{ }$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\sqrt{ }$ |
| Mark | $\sqrt{ }$ | $\sqrt{ }$ | $\sqrt{ }$ |  |  | $\checkmark$ | $\sqrt{ }$ |
| Matt | $\sqrt{ }$ |  |  | $\sqrt{ }$ |  | $\checkmark$ |  |
| Robert | $\checkmark$ |  |  | $\checkmark$ |  |  |  |
| Sandra | $\sqrt{ }$ | $\sqrt{ }$ |  | $\sqrt{ }$ |  | $\checkmark$ | $\checkmark$ |
| Scott | $\checkmark$ | $\checkmark$ |  |  | $\checkmark$ |  | $\checkmark$ |
| Sophia | $\checkmark$ | $\checkmark$ |  |  |  |  | $\checkmark$ |

## Key findings related to Research Question 1 Sub-Question 2.

The themes that emerged from the cases related to the coaches' experiences were placed under the three points of Research Question 1 Sub-Question 2. These three points are shown in Figure 5.6 and will be the headings for the following discussion sections.

Figure 5.6. The three main categories of Research Question 1 Sub-Question 1B.


## Coach knowledge growth.

Because she is not a science teacher, Laura indicates that most of her science knowledge comes from helping students and observing other mentors while they are working with the students. "I am amazed that I could watch jeopardy and get answers [correct] because of Science Olympiad, you know. I am not a science teacher." Other coaches did not mention in the interviews that they gained knowledge from participation.

## Coach skill growth.

Most coaches did not mention learning new skills. Scott mentions learning to deal with different student personalities. Laura and Scott both imply that financial skills are beneficial. Several of the coaches' comments indicate that people and networking skills are important for finding and recruiting volunteer coaches either from the community or other teachers.

## Coach personal growth.

On the questionnaires, coaches discussing increased personal knowledge seemed to enjoy the reason to continue learning. One of the retired teacher community volunteer coaches said, "[Science Olympiad] keeps me learning and interacting with students." Coaches who are the
sole coach at their school commented that the need to become an "expert in many disciplines" to mentor 23 events was a benefit in spurring them to broaden their knowledge base even if they also considered it a drawback for the students not to have an expert mentor. One coach commented that he enjoyed being "challenged to learn to figure out their questions." In all, coaches felt that the need to be more knowledgeable in areas outside of their major field, and therefore learn more, was a positive for their profession. As one coach put it, "[SO] keeps me up to date on recent scientific breakthroughs."

Building lasting relationships with students was the most common response to the benefits question in both interviews and on questionnaires. Being able to work with students for more than the one year or two that they might have them in a science class enabled this friendship building and teachers commented on still being in touch with former Science Olympiad team members that had graduated from college and were out in STEM related careers. Hearing about these former students' successes and how Science Olympiad benefited them brings a lot of personal satisfaction to these coaches. Being able to learn about a student's strengths outside of the classroom was seen as a very important benefit for the teacher in being able to better relate to students in the classroom and helped the teacher give more effective instruction.

Networking and building relationships with colleagues who also coach Science Olympiad was seen as helpful to coaches. The support that the coaches give each other, even from different and competing schools, seems to be highly valued by the coaches. Several of them commented on enjoying meeting people with similar interests and making new friends. The coaches see camaraderie as an important thing for their students. Through their interview
comments, questionnaire responses, and my observations in the coaches' lounges, it appears that it is just as important for the coaches themselves.

Personal satisfaction is the underlying theme in the benefits comments. Coaches participate because it brings them personal satisfaction in one or more ways. These ways include the opportunity to build relationships with colleagues and students, having a reason (or excuse) to learn new STEM topics, enjoying watching students get excited about learning, and maybe just having fun themselves.

## Key findings related to Research Question 2.

Student challenges to participation.
Most coaches indicate that most of the things students might find challenging result in the building of a skill or developing a coping mechanism. Therefore, these things are viewed as benefits by the coaches. However, there are some things displayed in Table 5.4 that coaches mention are difficulties for students.

Table 5.4. Challenges Coaches See Students Encountering

| Coach | Time Conflicts | Overcoming <br> Procrastination | Overextending \& Burnout |
| :---: | :---: | :---: | :---: |
| Anne | $\checkmark$ | $\checkmark$ |  |
| Barbara |  |  |  |
| Beth | $\sqrt{ }$ |  |  |
| Kelly | $\sqrt{ }$ |  |  |
| Laura | $\sqrt{ }$ | $\checkmark$ | $\checkmark$ |
| Leslie | $\sqrt{ }$ | $\checkmark$ | $\checkmark$ |
| Mark |  |  |  |
| Matt | $\checkmark$ |  |  |
| Robert | $\checkmark$ |  | $\checkmark$ |
| Sandra | $\checkmark$ |  | $\checkmark$ |
| Scott | $\sqrt{ }$ |  |  |
| Sophia | $\sqrt{ }$ |  |  |

Most of the coaches interviewed mention the time commitment required for Science Olympiad participation. Other school activities are also cited as pulling students away or conflicting with practices and competitions. Sports and music were the two most often mentioned. Jobs and family pressures were also given as reasons students missed Science Olympiad activities or quit completely. Coaches do not see drawbacks otherwise. When asked about competition pressures, the coaches did feel it was not a major issue with the students because they helped the students see the positives and the teammates were supportive and encouraged each other to continue after disappointments.

There is a large time commitment required of team members if they want their team to do well in competition. Coaches were asked in the interviews if they saw a "hyper focus on winning". If a team does not do well or members of a team do not do as well in their events as other students did in other events, it can lead to a "sense of inadequacy when compared to other
peers". However, the coaches interviewed, when asked specifically about this, did not see this as an issue. They indicated it could be possible with some teams, but they and other coaches they knew tried to keep students focused on how what they were learning was more important and how Science Olympiad was benefiting them and their future more than an award. This did not mean that the coaches did not encourage the students to try to win, but they tried to let them know that winning was not the most important thing, and they were proud of the students' accomplishments.

## Challenging experiences for coaches.

When discussing the difficulties that they had to overcome, coaches talked mostly about lack of support both financially and in manpower and the struggle to keep students involved.

Figure 5.7 shows these three main topics and some sub points under each of them. Each of these points is discussed.

Figure 5.7. Research Question 2: Challenging Experiences for Coaches


## Lack of funding for the Science Olympiad team.

When discussing challenges, coaches dwell mostly on lack of funding for the Science Olympiad team. Specifically, the need for equipment and money for travel were mentioned. As previously discussed, participation in invitational tournaments is beneficial to the students. Beth discusses her trouble with travel expenses. "If we were a recognized team event, then our school would pay for our bussing. Bussing costs have just gone up tremendously in the past few years." Beyond the vehicle expense, there are also entry fees and possible hotel costs if the invitational is a great distance. Barbara (Appendix H) overcomes small school funding challenges by having bake sales. She says that she has a lot of parents that can bake well. "Money," Scott (Appendix Q) says. "Boil is down to one word, it's money. If you have the money, you can travel. If you have the money, you can buy the supplies and you don't have to rely on the parents."

Financial challenges faced by Science Olympiad teams.
Most coaches interviewed named finances as their greatest challenge. This is due in part to the fact that many of the challenges facing coaches can be solved by money. Two of these emphasized by the coaches are transportation and materials. Some teams are limited to the number of tournaments they can attend because of the cost of transportation. Transportation is more than just the bus. The students also need to be fed and each tournament has an entry fee. Currently, with the scarcity of invitational tournaments in many parts of the states, hotel costs are also a part of the equation due to the distances some schools must travel just to compete. The importance of attending competitions has already been stated, so it is easy to see how this can severely hinder the ability of a team to be successful or even continue to exist the following year.

The acquisition of equipment and materials for builds can be expensive. Especially in the first year the expenses can be quite high due to the one-time expenses of certain equipment such
as microscopes. After the first year there is still the expense of replacing consumable materials and kits required for the building events.

One strategy for overcoming the initial cost of starting a team is to get a grant or donation from an organization promoting STEM activities in schools. Local businesses or organizations can be asked to sponsor the startup of a Science Olympiad team with a large one-time donation. After the initial year, local businesses or organizations can be asked to continue support with smaller donations. Local hardware stores may be willing to donate some materials for the builds. Other sources of income can include school fundraisers. Coaches most commonly mentioned having the students run concession stands for sporting events.

The coaches interviewed expressed a belief that more competitions (invitationals) benefited the students because they allowed the students to practice the events before the highstakes regional tournament. Builds could be tested under conditions different from the school practice room and students in paper testing events could be exposed to a greater number of tests by different authors. Both enable the student to return home and tweak their builds, modify their note folders, or develop a different study approach. For these reasons, coaches stated that being able to afford to attend more tournaments was of great importance to the students.

Scott (Appendix Q) wants the students to have as many opportunities to compete as possible because that gives them more opportunity to medal and obtain the tangible reward for the knowledge and skills they have gained. Leslie says in Appendix L that her students would be more engaged if there were more competitions. No coach stated that they thought there were too many tournaments. Several coaches expressed that they would like to see the first tournament of the year come much earlier than the current practice of starting in December. They state that it is hard to maintain student interest and motivation from September until December. Late

September or early October tournaments would give students feedback earlier in the year so they could begin the tweaking process earlier and not be so long in a holding pattern where they can lose interest. It also helps the coach to better identify the consistently strong students in each event and build a better qualifying team for the regional tournament.

## Lack of non-financial support.

Forms of support coaches reported they received varied by degrees and types of things they perceived as support. The combination of sources for each coach was different. The one type of non-financial support which most coaches agreed is critical for having a team capable of qualifying for the state tournament or beyond is the volunteer coaches who are experts in their fields. Most coaches expressed difficulty in being able to mentor students in all event areas. Winning team coaches tended to attribute their success to having expert coaches for each event area while other team coaches attributed at least in part their inability to win against certain schools to the lack of access to this expert mentoring.

## The role of volunteers in Science Olympiad.

Two coaches talked about running their own invitationals and how that was a source of income for their teams. This helps solve one challenge but brings up the challenge of volunteers. As previously described, it takes many people to run a tournament. Asking the participating teams' coaches to run events doesn't cover every event. Parent and community volunteers must be called to have enough people. Non-competing students and members of service organizations such as National Honor Society and Scouts BSA volunteered to help with different aspects of the three meets observed during this study.

There is also a need for another type of volunteer besides those helping on the day of the meet. As already mentioned, coaches agree that it is better for the students and enhances the team's competitiveness when each event has a dedicated coach. The source for these volunteer
coaches is mostly community members with expertise in the field of the event. Again, smaller communities have a challenge with finding volunteers for certain events if there is not local employment for people in those fields.

Scott in Appendix Q met the challenge of getting the team enough practice without having to travel constantly to out-of-state meets by holding weekly mini competitions after school. Each week a different event is held. Anyone can enter and all team members are encouraged to enter even if they don't intend to compete in that event. The coach uses it to identify who will make up the competitive team when they do travel and also to uncover students with unexpected talents in certain events. These also help motivate the students to get involved in preparing for their events earlier in the school year, which was a challenge mentioned by Leslie in Appendix L who was lamenting the fact that the first meet in her state was often not held until December. She stated that students were hard to motivate until about mid-November and she wanted some way to get them involved in September.

Coaches and mentors volunteer because they enjoy watching students succeed. The stories related by coaches in the interviews convey the joy and satisfaction that coaches feel when students place, or the team does well. However, tournament success was not the only source of this benefit for coaches as was evidenced by the stories that related students overcoming personal challenges.

## Recruitment and retention of participants.

The third challenge that coaches mentioned experiencing is the constant struggle to recruit and retain students on the team. The number one issue cited was the constant pull for the students to do other things. Mostly these were time demands by other school clubs or sports forcing the students to either spend less time on Science Olympiad or to choose between the two
with the pressure to give up Science Olympiad altogether. Some coaches expressed that having a dedicated time during the school day alleviated some of this issue.

All coaches recognized that small schools were especially challenged for several reasons.
Having a smaller student population from which to recruit and pull together a full team was the factor given the greatest weight after finances. Teams that cannot cover all 23 events are at an extreme disadvantage in even placing as a team at an event. This means that only individual students have a chance at feeling the success of winning or placing in individual events and the feeling of shared success when the whole team does well is often not possible for teams from small schools. Most of the coaches had experienced coaching in a small school setting at least once in their Science Olympiad career.

Coaches did not report that Science Olympiad involvement caused them to develop new skills in their area of STEM expertise. A few commented that Science Olympiad helped them to maintain certain areas of knowledge. Some of the smaller school coaches who coach all the events without the help of assistants commented that they have gained knowledge in topics outside their original subject areas to be able to mentor students in those topic areas.

For Sophia in Appendix R the two-county rule imposed upon homeschool teams seems to be particularly burdensome and hindering in her ability to recruit students. It also appears at least on the surface to be unfair from her perspective when one considers that some of the brick-and-mortar schools pull students from more than a two-county area. In the case of Sophia's team, they competed against a boarding school that had foreign students and students from other states on their team. So, the rule appears to her to be a double standard specifically designed to penalize and discourage the involvement of homeschool teams.

Coaches from small schools that have a difficult time recruiting a fifteen-member team see their students taking on a lot of stress and overworking themselves in an attempt to cover all of the categories. The coaches interviewed did not indicate that they did this or had done this when they coached at a smaller school. Leslie (Appendix L) stated that she made no attempt to try to cover all the events with half a team. However, in giving advice to new coaches, it was recommended to enter all events even if the student just signed their name on the test and did not really take it. This sounds good in theory but may be difficult for a competitive student to accept. If asked to go into an event a competitive student is going to feel like they must do their best. The first time it might be fine to just sign a name, but if they are going to be asked to do that every tournament, the student is likely to feel some pressure (even if just self-imposed) to study at least a little for that event.

Science Olympiad is a competitive team, and the mindset seems to somewhat parallel that for sports teams. Students who put in the effort will typically do well and those who do not do not do as well. Those that do not do well will either decide to work harder or they will quit the team. The sports attitude of not everyone is cut out to be an athlete seems applicable here as well. Not everyone is cut out to do science.

Science Olympiad takes a large time commitment. This is a statement agreed upon by all coaches and, therefore, is a key finding.

## Coach burnout.

Most coaches acknowledge coach burnout, and several admit to having experienced it personally. Reasons cited for burnout are that Science Olympiad does require a fair amount of time and other teaching responsibility can take away from the time a teacher has available. The need to continuously recruit more students and acquire financial support can also wear away at ones' energy. Scott admitted in Appendix Q that doing the same thing every year got tiresome.

He is the only coach to offer a solution to the problem. A new assistant coach joining their team brough in new ideas and reinvigorated the entire program. This example lends support back to the need for a team to have multiple coaches for yet another reason. Being able to rotate some people on and off the coaching staff or even just changing the events they coach from one year to the next can help them see the events from a new perspective and keep things more interesting.

## Key findings not specifically related to Research Questions.

## Effect of school size.

In schools where we see one school coach for all 23 events, responses to the support questions often convey frustration in those coaches who feel isolated. These coaches say that they get verbal encouragement from school administration and teacher colleagues, but they are alone in mentoring students. These coaches praise parents for simply dropping off and picking up the student team member. Parents who go above and beyond by providing materials and occasional snacks for the team are cited as exceptional volunteers.

In some cases, the same coach is coaching both the high school and the middle school teams. In several one of those locations, it was indicated that the two schools were close enough that students could walk from one to the other after school. In other situations, the schools were not anywhere near each other. Student transport to the school where the teacher was located was not feasible requiring the teacher to travel between schools transporting materials. An example from the questionnaires of how burdensome the toting of materials can be viewed is that one community volunteer for a school indicated that the school providing a place to store the materials for the one event he coached was a factor in his willingness to volunteer. That is one event. Not all events require materials, but a teacher who is the sole coach responsible for mentoring 23 events would have to transport materials for multiple events.

The specialization of knowledge for some of the events makes it difficult for one person to be able to maximize team success in all categories. Each event is scored, and winners are recognized at the awards assembly at the end of the day. Participants also receive points for how they ranked in each event they entered. These points are totaled up for every team and top placings for schools are named at the end of the awards. In this way, the SO recognizes both individuals and teams. This means that a small school with a few highly motivated students can dominate an event or two and be recognized for their efforts even if their school is not able to field a team that can cover all of the events. In contrast, some large schools have more than one team because there are more than fifteen students interested in participating.

These larger schools will fill out one team with experienced Olympians and then add newer members if needed for uncovered events. The second team consists of new members who are getting experience. Students get pulled off the second team to fill in on the first if someone cannot make a tournament much like first and second strings on a sports team.

Small schools tend to view themselves as being at a disadvantage for progressing to state or national competitions. Some states require a team to place in the top number at Regional tournaments in order to compete at the State tournament. Other states allow all teams that want to compete at the state tournament to do so. It depends somewhat on how many teams are in that state. The top winner of the state tournament progresses to the Nationals. Schools that can always field at least one full team with participants in all events guarantee that they get at least some points in every event. Even if they never take top ranking in a single event, at the end of the day they will score higher than the five-member team that won three events but were only able to enter 10 or 15 events. There is no limit to the number of events a student can enter, but event scheduling at the tournament can make it difficult for a student to be in more than a few
events because they cannot be in two places at the same time. Some events require teams of two, so that keeps multiple students occupied in one event. At the tournaments, individual event judges may allow some flexibility in timing to allow for a student to compete in one event and then be late for a second one in the same time slot.

Interestingly, school size may not be the main factor affecting a team's ability to take top rankings and progress to the state or National tournament. In these competitions, there are a few private schools that are considered small by student body but are situated in a large city. Some of these schools suffer the same hardships as small schools in small communities where resources are limited because the private schools only have the support of their school families in the community. Other schools have the ability to pull support from the larger city community and can go head on with the largest public schools. During the interviews, it became obvious that one of the private schools was utilizing volunteer community coaches to completely mentor their team as opposed to a head coach handling most of the events and calling in some outside experts in a few event areas. This latter seemed the more common approach with the other schools that utilized community volunteers.

Whether or not they are being used solely or in conjunction with a head coach, this specialized knowledge in multiple areas can rarely be offered by one coach. Some coaches cited the need to know and be able to teach 23 different events as the major challenge they had to coaching. They felt that it was impossible for them to effectively instruct students in areas for which they had no background and only a few months to scramble around for materials in order to learn themselves. Having these community volunteers relieves some strain on the coach allowing them to focus on helping students in their personal area of expertise and also on team logistics like planning attendance at tournaments, procuring transportation, food, and lodging (if
needed) for those events. If the school does not financially support the team, then the burden of planning, getting approval for, and coordinating enough fund raisers to meet the team's expenses falls to the coach. As is shown by the example of Laura's team in Appendix K, available community resources are possibly more a factor influencing team success than the size category of a school.

## Stipends and financial support.

Eight of the twelve coaches interviewed received a regular stipend. Of the others, Laura received a bonus one year due to success at Nationals and a very supportive Priest and School Administrator who worked to get that for her, but it was a onetime only occurrence in her 20year tenure as a coach. Anne in Appendix G does not receive a stipend because coaching SO fulfills the extra duty requirement at her school. Sophia (Appendix P) is a homeschool coach and so there is no school to pay her a stipend. Barbara did not say in Appendix H if she received one. Table 5.5 shows which coaches received a stipend, the amount and whether they kept the money or put it back into funding their SO programs. Three of the eight coaches receiving stipends reported that they spent the money back into supporting the program themselves instead of keeping it personally as compensation for personal time spent. Most also reported that their stipend was less than that received by sports coaches at their school. Robert (Appendix O) reported receiving the same as an assistant sports coach at his school whereas other coaches reported receiving a lesser stipend than a sports coach.

Table 5.5. Coach Stipends

| Coach | Received Stipend | Put Money Back into <br> SO | Amount of Stipend |
| :---: | :---: | :---: | :---: |
| Robert | Yes | No | $\$ 2000$ |
| Kelly | Yes | Not stated | $\$ 1600$ |
| Scott | Yes | Yes | $\$ 650$ |
| Leslie | Yes | Yes | $\$ 400$ |
| Beth | Yes | Yes | Not stated |
| Matt | Yes | No | Not stated |
| Mark | Yes | No | Not stated |
| Sandra | Yes | No | Not stated |
| Anne | No | - | - |
| Laura | No | - | - |
| Barbara | Declined to comment | - | - |

Most everyone except Laura says that financial support for the team is the most important type of support followed by administrative support. This could be due to a lot of financial support being funneled through the administration. Laura names community support as more important than administrative. This is interesting for several reasons: 1) Her financial support has come from the community and not the school for the most part. 2) Her coaching staff is from the community and not from the school. It is also interesting to note that she has had one of the most successful teams (in terms of going to the national competition) of the coaches interviewed.

The coaches interviewed in this study have an open-door policy for taking all comers into Science Olympiad. For the states represented all meets except Regional and State allow a school
to bring multiple teams. The only factor inhibiting student participation appears to be financial. Beth (Appendix I) states, "I mean, we can only have one team participating in Regional and State, but if we go to an invitational, we can take as many teams as we can fund." Scott in Appendix Q also supports this idea in his statement about deciding to take advantage of the second team option when his state added it back. "We're going to take advantage of that because we want to give those kids the experience."

## Some students want and need competition.

It is not uncommon for Science Olympiad coaches to coach something in addition to SO. Competitions such as Robotics and other STEM competitions are mentioned by Mark (Appendix M) and Leslie (Appendix L) specifically. Some coaches said they sponsor other competitions because they think more opportunities for the students to compete provides more learning experiences for the student. Mark commented in Appendix m that students need goals. Competition is a motivator. Students could do builds and test them for fun as a club activity or they could test themselves over subject area knowledge as simple measures of increased knowledge without a competition. However, several coaches commented that students often do not study or test their builds until there is an approaching deadline. Competition can also be a validator. Success confirms to students that they are knowledgeable in their chosen area.

## Students want a place to belong.

Science Olympiad gives students a place to belong. Coaches mention the necessity of having room for the students to store materials and meet. Even if it is just a storage room, the common area is important for the students to feel like they have a space that is theirs. Storage space is a minimum, but also a space where students can come to work if they get finished with another class early helps the students get the prep time they need. Also, a physical room can allow them to work before school or during lunch. This set aside place is not just a work or
storage space. It is a social place. Students socialize while they work. Coaches mention the importance of food as part of the social aspect. Team members develop camaraderie as they work and sometimes play together in this special place. Older team members mentor younger team members. In some cases, becoming protective of their younger teammates and looking out for them in competitions and while traveling. Coaches used the term camaraderie in talking about this unity that is built.

This sense of belonging to a team does seem to include the students who are not on the "scoring" team (the team that is going to try to qualify for State/Nationals). Beth gives an example in Appendix I of how the students doing the same type of build will get behind the students with the best one after several invitationals and help them to improve for Regionals. There seems to exist a feeling that if the team wins, everyone wins. Just like in sports, the team members may change out. Students get sick and an alternate may need to take their place. Several coaches mentioned Band or Music competitions pulling students out of the State Olympiad.

## Competition structure.

Each state has its own structure for in-state competitions and qualifying for a Regional or State competition. At the National level it is determined how many teams each state can send by how many teams are in each state. For the states in this study, there were only one or two "required" meets for the teams. In some states the only required meet was the State meet. ("Required" is defined as being necessary for a team to ultimately advance to the National competition.) Any team in that state that wants to can come to the State meet. For other states, a team must place in a top ranking at a Regional to advance to State. Attendance at other meets is totally optional.

However, most coaches indicated that the more practice meets a team can attend, the better they tend to perform at the required meets. Getting to these extra meets can be an issue for several reasons. First, a school has to be willing to host the invitational tournament. Then, enough other schools must be willing to travel to that tournament. Distance is an issue in most of the study states for schools that are not in or near major cities.

One advantage to hosting an invitational beyond the home team gaining an additional practice opportunity without the travel expense is that it can make the home team money to travel to other meets or purchase materials. At one of the meets attended for this study, there was even a concession stand doing booming business for the home team. Invitationals also do not have state boundaries. At the two State C invitationals attended for this study, there were teams from State A, State B, and State D. A State B coach who has sponsored an invitational for several years has often had teams from six states attending with more than 1000 students. Some of these teams were defending state champions from their respective states and willing to drive in some cases across a state and a half to get more practice before their Regional or State meets.

Smaller schools with limited travel budgets are at a disadvantage for attending these practice opportunities. It would seem a simple solution if every school would just hold an invitational like every sports team hosts home games. However, there are several logistics factors that must be taken into consideration. The school must be large enough to physically house room for 23 events and then have the personnel to run those events. It is a standard practice that every team attending must run an event. Therefore, if you have 23 teams competing, the personnel problem is solved. That, however, is a huge meet.

Just hosting a tournament doesn't mean that teams will come. As described by several coaches, if there is both a middle school and high school team, it is beneficial financially to bring
both teams to the same meet as opposed to separate ones due to the expense of travel. This means that to be attractive for other schools to attend, a meet needs to offer both levels of competition. Now the hosting school must have room for 46 events and the personnel to run them. Though some overlap of rooms and personnel can occur, it is still a large amount of space and people.

## Evidences that the stated goals of the Science Olympiad are being achieved.

Goal 1: To create a passion for learning science by supporting elementary and secondary Science Olympiad tournaments at building, district, county, state and national levels with an emphasis on teamwork and a commitment to excellence.

Coaches do talk about students finding their passion in relation to certain event topics offered by SO. As to whether SO "creates" the passion or simply uncovers a students' passion could open debate about the wording of this goal. The structure of the tournaments does emphasize teamwork and coaches are reluctant to go against that and allow individuals to enter events alone. Coaches typically allow that only if a partner is unable to attend that tournament and no substitute team member can fill in. The phrase "a commitment to excellence" is vague and open to interpretation. Who determines what is "excellence" and an excellence in what specifically?

Goal 2: To improve the quality of K-12 science education throughout the nation by changing the way science is perceived and the way it is taught (with an emphasis on problem solving and hands-on, minds-on constructivist learning practices). This goal is accomplished through in-depth core curriculum training workshops and the distribution of curriculum materials.

This goal states that SO wants to change the way science is perceived and the way it is taught. To measure the first part of this, a baseline of how science is incorrectly perceived needs
to be established and a statement of how SO would like for science to be perceived needs to be made. Otherwise, there is no way to know if a change of perception has been accomplished or if that change is the one desired. In changing how science is taught, this study indicates that SO has very little influence over what is done in the regular science classroom. Mark comments that he is usually too focused on getting the required material covered and does not feel that he can give students time explore during regular class. Robert is similar in talking about how broad the teaching in the classroom must be to cover everything and there is not room for the depth that SO encourages.

The spill over into the classroom from the instruction side seems limited in some cases to non-existent in others. Matt comments that he does pull some activities and concepts into his regular classes. Sophia mentions what is possibly the greatest application of SO in curriculum with the parents of homeschooled middle school students using the Division B topics to provide the focus of the curriculum for their students. However, in most cases the learning opportunities offered by SO are relegated to after school exposure for the group of students interested and do not benefit nor impact the average student in the classroom.

Workshops are mentioned by the coaches as useful for understanding how to compete in the events, but none of the coaches who were teachers related that the instruction or any materials received during workshops were used outside of SO team preparation.

Goal 3: To celebrate and recognize the outstanding achievement of both students and teachers in the areas of science and technology by awarding thousands of certificates, medals, trophies, and scholarships.

There is no doubt that students are recognized during SO competitions. Several descriptions of the awards assemblies and the student excitement around these support that the first part of this goal is achieved.

However, no mention was made by study participants of teachers being recognized in any special way. It is unknown from the data in this study if SO has a system for awarding outstanding coaches or by what method SO intends to "celebrate and recognize" the teachers.

Goal 4: To promote partnerships among community, businesses, industry, government and education.

This study did not reveal any evidence of the national organization encouraging any of these types of entities to seek out SO teams in their area to sponsor, become tournament sponsors, or provide any other type of assistance to SO teams. The coaches in this study had relied on their own devices to find and develop these connections if they had any. Some coaches found this more challenging than others and some had communities and surroundings with more resources to achieve this than others. If SO is achieving this goal, it is vicariously through the individual efforts of the coaches and not by a direct effort of the organization to promote this for the benefit of the teams and named entities.

Goal 5: To bring science to life, to show how science works, to emphasize problem solving aspects of science and the understanding of science concepts.

Comments made by coaches and examples related in the sections discussing student content knowledge give evidence that this goal is being met through participation in the SO program.

Goal 6: To develop teamwork and cooperative learning strategies among students.

Comments made by coaches and examples related in the student skills section on teamwork give evidence that this goal is being met through participation in the SO program.

Goal 7: To make science education more exciting so more students will enroll in science courses and engage in other science activities like science reading, fairs, meetings and field trips.

This study did not reveal any evidence to support that this goal is achieved. Coaches indicated that most participants were already interested in science. Additionally, since the time requirements for SO were considered the leading challenge for students to continue participation, this implies that SO participation precludes participation in other science related activities. An exception could be the science reading activity since all team members competing in testing events will engage in reading a large amount of material related to their topic in order to build their binders or note sheets.

Goal 8: To promote high levels of achievement and a commitment to excellence, to demonstrate that American students can perform at levels that surpasses expectations of even practicing scientists and engineers.

This is a vaguely defined goal and, therefore, difficult to say if there is evidence to support it. Who determines what are "high levels" and defines "excellence"? Determining if these aspects of this goal are being achieved requires some basis of comparison to what would be considered not "high level" or not "excellent". For the second part of the goal statement, that question must be asked: What are the "expectations of practicing scientists and engineers"? Is there a consensus on this and, if so, is there a place where this consensus has been published in order to make a comparison?

Goal 9: To attract more students particularly females and minorities to professional and technical careers in science, technology, and science teaching.

Coaches in this study do give examples of female participants. Two coaches mention females of minorities specifically. Anne talks about how the team at her school has been diverse since her student days. This is evidence to support the participation of females and minorities and, therefore, the potential that this goal may be being achieved. A long-term study following female and minority participants through school into careers would be needed to ascertain if this goal is being achieved.

This goal analysis section exposed that there may be some issues with the wording of the goals as stated by Science Olympiad if these goals are to be measured with outcomes. This study provides evidence that Goals 5 and 6 are being achieved. Evidence suggests that Goals 1 and 3 are being achieved in part and that Goal 9 is potentially being achieved. No evidence for Goals 4,7 and the second part of 2 was provided by this study. The remaining Goals of 8 and the first part of 2 need better defining to allow a method of measure for achievement.

## Linking Key Findings to a Review of the Literature

## Science Olympiad offers students opportunities for personal growth.

Coaches report that SO provides exposure to new STEM topics which can lead them to discover specialty fields with area of interest that may lead to future careers. This supports the findings of Smith et al. (2019). Deeper knowledge acquisition is also mentioned by many coaches. This coincides with the findings of Wirt (2011) and Schmidt (2014). Wirt's (2011) study investigated participants' perception of their learning while involved in the Science Olympiad. The responses revealed that some students felt that they learned more while immersed in the Science Olympiad activities than while in a regular classroom. This is supported by comments in the qualitative portion of Schmidt's (2014) study where students stated that they enjoyed being challenged by material above the level of that in the classroom and being able to study a topic in greater depth.

Scott says in Appendix Q that Science Olympiad participation enhances student knowledge. When an event is directly related to a class or a specific subject within a class Scott says, "They're pretty much going to ace the tests that we give them because they already have that knowledge." He says that preparing their notes for the event tests helps them to become "more efficient, studious students" in their everyday classes. "And the test scores they show that, I think, across the board they reflect that." Leslie (Appendix L) also supports this saying that she sees students reference things from their events in answers on classroom tests. Most coaches commented that students learn a greater depth in an event area than they will be exposed to in a classroom and, depending on the event, might learn detailed knowledge in a field that is only mentioned in the classroom.

## Science Olympiad enhances science literacy.

One of the stated goals of Science Olympiad is to improve the quality of science education. The term science literacy is not specifically used in the statement. The statement says Science Olympiad wants to encourage "an emphasis on problem solving and hands-on, minds-on constructivist learning practices" (Science Olympiad website). However, Science Olympiad has published on their website a listing of each of the NGSS standards that is fulfilled by each of the Science Olympiad events. Therefore, even though science literacy may not be a stated goal of the Science Olympiad, it is recognized as at least an important by product which coaches may wish or need to document.

As discussed in Chapter 2, there are numerous views on the definition of science literacy and even varying views on how to define general literacy which then affects how to define the more specialized literacy of science. One view of general literacy promoted by UNESCO (2017) is that there is not one literacy for all, but that literacy exists on a continuum where a person acquires the level of competency they need for their livelihood and areas of interest. NGSS
(NRC, 2013) can be viewed to align with this concept. Science Olympiad also functions well along this continuum. The standards for literacy are discipline specific and as the standards become more specialized a person can choose to be literate in some areas and not in others. It is not necessary or even practical for a person to be literate in all areas of science. As Hazen and Trefil (2009) stated, "Indeed, it has been our experience that working scientists are often illiterate outside their own field of professional experience" (p. xiii). Science Olympiad allows for students to focus on the areas in which they wish to be more literate.

What level(s) or type(s) of literacy does Science Olympiad allow participants to reach? The first type of literacy according to UNESCO (2017) is literacy as a stand-alone skill and is described as word and symbol memorization. Bybee (1997) uses the term nominal literacy and Shamos (1995) calls it cultural literacy. It is being able to understand the jargon but not able to go beyond that. Beth (Appendix I) feels this is at a minimum an important function of Science Olympiad. She relates her personal story of her struggles in aeronautics because she had not been exposed to the jargon where many of her college classmates had been. She thinks that if Science Olympiad provides nothing more for a student than an introduction to the terminology for their area(s) of interest, it has provided a great service for that student's future. She cites this as one of the reasons why she also tries to make a place for students who are interested but cannot be on the team due to conflicts or other reasons. She says, "Just hearing the ideas and the concepts being discussed is important."

The next step along the continuum is labeled functional literacy. Bybee (1997) describes this as the ability to use scientific vocabulary within a specific context and consists of mostly memorized terminology. This type of literacy fits some of the goals of the NAS and NRC. It is also easily assessed in multiple choice tests. Most Science Olympiad event categories have a
multiple-choice test as part of the competition to gauge this level of knowledge among participants. It is somewhat easy for coaches and participants to determine the participants progress for this type of literacy in specific events by simply looking at how results improve from one competition to the next (though some variation in tests between competitions can account for some variations in performance results).

Science Olympiad can take the participant further along the continuum to what UNESCO (2017) terms literacy for empowerment and says that a person with this literacy is able to question and understand the world. This is also termed literacy for citizenship. A definition in NSES states, "Science literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions" (NRC, 1996, p. 22). Strand 2 of Taking Science to School says it is the ability to "generate and evaluate scientific evidence and explanations" (NRC, 2007, p.334). Reading articles is the first step most coaches discuss for student preparation for the testing events. Coaches talk about the time commitment required for a student to build their study binder. These binders consist of discipline specific articles that the participants will study in preparation for the event tests and in many cases must be sifted through and distilled down into a more concise form that the participants can take into the event with them. As described by the coaches, events are entered by partner groups who often divide up the field specific topics between them so that each has their own area of expertise to be able to answer the questions and perform the tasks within the imposed time limit. Preparation for this requires some amount of discussion of the researched articles between the partners and sometimes with a mentor to determine what is important information to take into the event and which falls into each partner's area of expertise. Most of the Science Olympiad testing events have a practical lab portion that
the participants must complete and either answer questions about or write a short report discussing the results. This further develops the participants' ability to evaluate conclusions and communicate those findings to others.

Shamos gives another description of this level of literacy and says it is being able to "choose one's experts wisely" $(1995$, pg. 86). Matt states that one of the important things that Science Olympiad teaches participants is that they sometimes need to seek out experts for help and he encourages his students to do this. All coaches agree that students benefit from having expert mentors for their event categories. Not all students or schools are able to find these. Though Shamos' statement carries an implication that not all experts are equal and that this level of literacy carries the ability to decipher who is a true expert in an area from someone who is just making claims, Matt's comments in Appendix N indicate that it is often a big step to get a student to acknowledge they need to seek out an expert and then to communicate with that expert. So, Science Olympiad helps develop the beginning stages of identifying and utilizing experts.

The fourth type of literacy described by UNESCO (2016) is literacy as social practice and considers issues of who needs the literacy and for what use. It acknowledges there are different kinds of literacy for different purposes. This indicates a recognition of forces influencing the social practice of literacy. In science, there has been some debate over how to define this for science. The issue of science education for science content versus science education for the understanding of science based social issues dominated discussion during the 1980's (DeBoer, 2000). To put this into other terms it is a conflict between science literacy for citizenship and science literacy for professionalism. Science Olympiad was born during this time and reflects in its event design a desire to offer opportunities for both types of literacy. Following along the
idea of a literacy continuum, the two are not mutually exclusive of each other. The NGSS (NRC, 2013) document aligns with the UNESCO (2017) idea of literacy as a continuum along which people move to the point of their need. This is science literacy as social practice. Not requiring everyone to train to be a scientist but allowing everyone the opportunity to gain the science literacy needed for careers and individual quality of life. Science Olympiad provides exactly this. Participants are encouraged and allowed to delve as deeply into a topic as they wish. Whether that topic is to become that student's future profession or to remain a lifelong hobby will be determined by the student's desires and will also be the determining factor in how far along the continuum they pursue that particular literacy. Just as one coach pointed out that Science Olympiad is not for everyone, professional level science literacy is not for everyone.

In terms of measurable literacy improvement for the standards that are tested on state tests, Laura reported in Appendix K that her school's science scores improved dramatically the year after her school started Science Olympiad and have remained high when they had been very poor in the years prior. This cannot be attributed to an effect of the teacher who started the team was also a great Science teacher so, of course, the scores went up. The teacher who started the team left after the first year and Laura, who has been running it ever since is a Social Studies and Religion teacher. She has said that in many years her small private school has struggled to get a qualified Science teacher and it is usually a math teacher that teaches both subjects. She attributes the higher scores completely to the fact that she runs the equivalent of three teams and half to three quarters of the approximately 65 students enrolled on average in the school participate. Other coaches are reluctant to credit improved test scores or having higher scores than other schools in their area directly to Science Olympiad participation.

## Students want and enjoy academic competition.

Some research states that there is a belief among some educators that academic competition is not good for a student's sense of well-being (Fülöp \& Orosz, 2015; Fülöp, 2009). Results of this study help to refute that belief and support Ozturk and Debelak (2008) who describe five benefits of competition: motivation, dealing with a competitive world, coping with subjectivity, a healthy self-concept, and interacting with supportive role models. Additionally, Abernathy and Vineyard (2001) showed that students choose to compete because they think it is fun. All six of these benefits are mentioned by coaches in this study.

In Appendix M Mark states, "...kids all have to have a goal. They have to have something to work forward or work to and feel like they know something and then they have to be able to share it with other kids." Mark's observation relates to goal orientation theory and the description of performance approach-oriented students who feel successful when they can demonstrate their competence (Höffler et al, 2016; Spinath and Steinmayr, 2012). Researchers claim that competitions suit students with this performance-approach orientation well but are concerned that students with other orientations (learning goal, work avoidance, and performance avoidance) may be discouraged and lose motivation to do science by a bad competition experience (Höffler et al, 2016). What the coaches see is that students lose motivation if there is not a competition. Scott and Leslie both lament the fact that the first tournament each year is not until December. They talk about how difficult it is to keep the students involved from August until November. In November the closer deadline of one month or less gets the students motivated to work. Scott uses his mini competitions with his students after school to fill in the several month gap and keep the students interested from the beginning. He says, "The kids love that."

In discussing loss of motivation or discouragement after a poor competition performance, most of the coaches state that they see the opposite. Instead of losing motivation, students seem to gain motivation to work harder to do better at the next tournament. These students fit the description of learning goal orientation type and are like the spelling bee finalists mentioned by Kronholz (2010) who did not win but stated that they would resume studying and do better next time. The ideal competitor is most likely a combination of these two orientations (performanceapproach and learning goal). Work avoidance and performance avoidance-oriented students may be some of the procrastinating students that the coaches talk about who do not do their work until the week before competition, but then manage to pull out something in the end.

Matt (Appendix N ) ties goal setting and motivation together. "I think it creates a little bit of intrinsic motivation." He defines intrinsic motivation as internalized motivation where achieving the goal is the single reward. This fits with the definition found in the literature. Ozturk \& Debelak (2008) define intrinsic motivation as coming from within the student. Orosz, Farkas \& Roland-Lévy (2013) add it is when the focus is placed on the process of doing rather than the outcome. Matt thinks that when a student says, "'I have set a goal and I have achieved that goal.' It's a major thing for a young person to do." He believes this ability to set goals and be motivated to achieve them is very important. "It's a life skill that really would propel anybody to accomplish just about anything."

Taking students to competitions can motivate them to stay involved and be retained in the program from one year to the next. Scott says in Appendix $Q$ that they can get a lot of $6^{\text {th }}$ graders interested in Science Olympiad, but they must keep them involved so they stay part of the team. The ability in his state to take multiple teams to invitational and even regional tournaments means he can get and keep the younger students involved by including them on
alternate teams. He tells them, "You're not quite on the top team this year, but you're still going to regional to give you that experience." He says, "That has lit the fire in their eyes so to speak."

Competitions are training grounds to prepare students to deal with a competitive world and cope with subjectivity. If we do not teach students to compete in school, we are not preparing them to enter a world filled with competition (Verhoeff, 1997; Ozturk \& Debelak, 2008) placing these students at a disadvantage when competing within the job market. Therefore, proponents of these competitions see benefits to both students and society (Campbell and Walberg, 2011; Ozturk \& Debelak, 2008; Verhoeff, 1997) because one thing that school competitions like Science Olympiad can do is to ease students into learning how to compete in a low-risk environment. Several of the coaches mention that Science Olympiad is a low-risk environment. Anne (Appendix G) considers the invitational tournament setting to be a low-risk environment. "Does it matter if we come in second or fourth at a local tournament? No." Part of this is that invitationals in her state allow each school to bring more than one 15 -member team so everyone who wants to compete can go even just to see what it is like. "We want people to try it and get better. We don't necessarily need them all to be future national champions."

Several studies reported by Clifford (1991) indicated that students were willing to take higher risks in a game condition than in a test condition (where the results matter more). In one study, game condition participants chose items of a difficulty level one year higher than those in the test condition. Intellectual risk taking (IRT) is where a person uses adaptive learning behaviors in an academic decision situation for which the probability of success or failure is uncertain (Beghetto, 2009; Clifford, 1991). Informal game-type settings provide low-pressure competition opportunities where IRT is safer because it is not connected to a grade. Even though much of the Science Olympiad competition consists of students taking tests, the results are not
tied to a grade, permanent record or anything that carries any weight beyond that day. Therefore, Science Olympiad can be considered a type of game. Especially at the invitationals if one makes a mistake in front of one's peers, it is likely to be laughed off. Matt gives an example in Appendix N of a student who spent a lot of time and effort building a plane only to have it go down after two seconds in the air. He says the student responded with something like, "Ah hahaha. That's so funny. Oh, I can't believe that happened." Matt says, "Even if you mess up, it's still fun, which is OK."

Learning to cope with subjectivity or the judges' decisions when one does not necessarily agree is a valuable life lesson for students in that actual or perceived unfairness is an inevitable part of many decisions that will affect their lives (Ozturk \& Debelak, 2008). Scott relates in Appendix Q experiences where his team have had instances where rule interpretations went against them, and the students had to deal with feelings of being treated unfairly. Rather than dwelling on these as bad experiences, Scott used these to help the students understand that life does not always seem fair, and one must look at what can be changed, improved, or learned from the experience and move on to the next thing. He says that learning to deal with these types of life experiences is a valuable part of Science Olympiad." He describes the kids talking about how unfair they think it is and he asks them, "We know now. How are we going to take care of this?" Scott says those are experiences that help build character. "I think the building of character and that efficiency I talked about, and the preparedness pays dividends for the leadership qualities they'll need in life."

Research indicates that skill improvement is important for students' confidence development and a healthy self-concept. Individual academic achievement has been shown to have a positive effect on academic self-concept and career aspirations (Nagengast \& March,
2012). Students who perceive they have improved or gained skills and/or knowledge in their chosen event(s) gain confidence in those areas and may take important steps in building a healthy self-concept (Kuech \& Sanford, 2014; Ozturk \& Debelak, 2008). However, students can feel accomplished in their skills, but if those skills are never challenged, it can lead to a false sense of ability. Talented students, especially those from small schools, may experience the Big-fish-little-pond (BFLP) effect. The BFLP model states that students will compare themselves to their immediate peers to develop their academic self-concept (ASC) (Wouters, 2009; Nagengast \& Marsh, 2012). This may lead a student of moderate ability in a low performing class or school to overestimate actual abilities. Likewise, a moderate student in a high performing school may underestimate their actual ability. Both types of students can benefit from competition.

Coaches indicated that they saw more instances of the latter where students underestimated their abilities in science and were surprised by their successes in Science Olympiad. Laura gave two specific examples of this with two different girls previously mentioned who each found a talent in identifying insects where before they did not believe they had any science aptitude.

This type of student may suffer from low self-esteem and low ASC because of constant comparison to higher performing peers. These students are at risk of not choosing a science career despite having adequate ability (Nagengast \& Marsh, 2012). If a coach or mentor can lead this student to find the niche in which his or her science interests and talents lie and where the student may achieve success, then entering in a competition for this niche area can allow the student an opportunity to show that he or she has a particular talent and can introduce the student to other students with similar interests.

The only mention of a student fitting the overestimation of his abilities is the one Scott talks about who was a gifted student and his parents' expectations were that he would always be the best at everything. Scott relates in Appendix $Q$ that the student became frustrated when he and his partner continuously took second place to the same team at invitationals all year. Scott explains that a mentor in the form of the student's event partner was important in helping this student cope with the situation. The importance of mentors and interaction with supportive models is discussed in a separate section.

Students view competitions as fun. Interviews of students from spelling bees to various science and math Olympiads to science fairs show that fun is a central motivation for continuing to participate year after year. Abernathy and Vineyard's (2001) study showed fun to rank number one among the reasons for student participation. For some the challenges of the competition itself are fun. For others it is the accompanying social activities that are attractive. Wirt (2011) also found that the social aspects were important to the students. Sophia describes how after the meetings her team will play soccer outside the rec center where they meet and sometimes organize parties to be held there. Beth (Appendix I) and Laura (Appendix K) explain how they often have food at the meetings because the students enjoy socializing while they eat.

Competing is a means to gain access to participation in these and other accompanying activities like trips. Laura tells about the one big trip she tries to give her team each year and indicates that is the highlight of the year for many of the students. Similarly, Robert talks about the trips his team has made to nationals. Other coaches also mention how the trips are bonding experiences for the teams and the days spent at tournaments give the students opportunities for interactions with peers from their own and other schools that form and deepen friendships. The
interactions with like-minded peers from other schools and feeling like there is a group in which one belongs is for many the big pay-off for all the work.

## Mentors are critical for student success in Science Olympiad.

Fülöp \& Orosz (2015) cite research showing that a student's perception of competition is related to that student's coping behavior. They name these coping behaviors as balanced, narcissistic-dominant-aggressive, and avoidant-giving up. The literature indicates that educators fear that many students possess the latter avoidant-giving up behavior and will turn away from science if they have a bad competition experience. This is where coaches or mentors play a large role in determining the type of experience a student will have with Science Olympiad.

The findings of this study support statements made by Ozturk \& Debelak (2008) claiming that an adult guide is needed for students to "maximally benefit from participating in academic competitions" (p. 50). The experiences of the coaches range from that of Leslie and Mark, who are going it alone and coaching all 23 events to Beth (Appendix I) and Laura (Appendix K) who have expert mentors working with students in nearly every event for which they do not consider themselves well versed. All coaches agree that expert mentors are the best for the students in both the depth of knowledge these experts can share with the students as well as the amount of time they can devote to that one topic (or several closely related topics) as opposed to a coach who is trying to teach all event topics or even split it with another coach to handle 11 or 12 event topics.

A student who is well prepared to go into a competition is more likely to feel confident and feel less anxiety. Confidence and less stress can result in a better performance in the competition. Regardless of the outcome of the competition, the mentor's role includes being able to help the student interpret that outcome (Ozturk \& Debelak, 2008). In the cases of head coaches with expert mentors, the head coaches talk about helping students deal with
disappointment indicating that even though a student is being coached by a specialist, the head coach is still very involved in what is going on with each individual student. The head coach is also the coordinator.

A student will normally compete in at least three events. Therefore, the student might meet with three different mentors during the week to prepare for a tournament. The mentor may also be encouraging the students in between tournaments for their individual events, but the head coaches indicate that they are active in helping the students to process the outcome of the tournament for all event areas. An example from Laura in Appendix K is when a student pair does not place in the top ten in their event, then she gets together with the student and the mentor and asks, "Okay, what do we need to do to help you guys?" She says she does not demand that the students win all the time, she just does not want them coming in last and likes them to be in the top ten. She implies that if a student is getting enough help and putting effort into it, she is confident they can place in the top ten at a tournament.

Mark discusses in Appendix $M$ that he helps students identify their weak areas by giving them tests every once in a while, so they can see what they do not have covered. "Then we sit down and talk about some of those, then they go out and get the information." He says that he may get another adult involved in the conversation if he can get an expert volunteer for that area. Scott tries to keep it positive when he reviews the competition results with the students. "Well, you got this section right, so you're not that far off from doing well." He says that you just have to pick them up and boost their ego a little by telling them that you can see their potential. "I think the internalizing from the kids has to be there and it's really hard to pull it out of the kids if it's not there because ultimately it is their choice." Scott also told a story in Appendix Q about how some students thought they did very poorly in their event and then they won it. Their
response was that all of the other teams must have been really bad. Scott suggested to them that maybe they knew more than they thought they did. In this way Scott helped to frame how the student views the other competitors. Viewing another competitor as a friend, active partner, motivator, or comparative other can put results into a more positive and constructive light than regarding the other as an opponent or enemy because the former is associated with emotions such as love and respect while the latter are associated with hatred and fear (Fülöp \& Orosz, 2015). Another example of this also given by Scott is the previously mentioned example of the student whose parents expected that he would always win first place. When he and his partner continuously came in second to another team and he was doubting his ability, it took his partner to put the situation in perspective and convince him that they were not bad in the category it was just that the other team was a little better. This role of mentors (and even other team members) taking negativity and changing the attitude to produce a little more self-confidence aligns with the benefits of competition given by Ozturk and Debelak (2008).

## Limitations for the Study

A limitation to this study is that the findings are reliant on participant self-reported data.
There were no evidences of pre-tests or post-tests given by participants to support their claims of improvement or change for any of the themes discussed. Additionally, it was difficult to get coaches to schedule interviews resulting in the sample consisting of who was willing to talk to the researcher rather than based solely on questionnaire responses as the researcher had originally planned.

## Coaching Strategies and Advice to other Coaches

Most of the coaches interviewed were eager to share advice based on their experiences. They are welcoming to new coaches who want to get involved. The coaches are passionate about what they do and want to share that passion with others. Most of the coaches volunteered
information for helping a new coach without being asked in the interview. Several coaches gave examples of how they had assisted other coaches and some discussed how the help they had received as new coaches played a critical role in their staying involved and becoming the coaches they are today.

Figure 5.8. Coaching Strategies and Advice to other Coaches

- Coaches observe that students often do not get motivated to work on things if there isn't a deadline.
- Money and administrative buy-in
- Budget for entry fees and supplies
- Budget needs to include travel expenses to invitationals
- The school also needs to allow space for the team
- Recruitment
- Publicity
- Team structuring and building

There is a strong sentiment that increasing the number of schools with competitive teams would be desirable. Instead of being worried about more competition making it harder to win, they seem to have view that more teams involved could mean more invitationals and more opportunity to practice for qualifying tournaments. More tournaments give the teams more opportunities to learn. The builds seem to benefit the more times they get tested. Students participating in testing events tend to fine tune their notes after each tournament. So, they would also benefit.

## Deadlines serve as motivations.

Coaches observe that students often do not get motivated to work on things if there isn't a deadline. Several coaches commented that some tournaments earlier in the fall would be good
for motivating students to start working sooner in the year. With this in mind, it could be said that coaches' experiences are greatly filled with developing coaching strategies to overcome coaching challenges. The following section will discuss some of these challenges and the associated strategies presented by the coaches in this study.

## Money and administrative buy-in.

Money and administrative buy-in were the two main factors discussed in the interviews. It is possible to start a team without the support of the school administration, but it is difficult. If you have a funding source from outside of the school budget, then it can be easier. This makes it easier even if you have support. Then the administration only needs to see you are following school rules, give moral support, and approve travel. The school also needs to allow space for the team. The team needs a place to call their own even if it is a storage room. It is additionally advantageous to have the administration supportive enough to allow for use of school facilities to host an invitational.

It costs about $\$ 150$ to register a team to compete for the year. Schools that run multiple teams pay a separate fee for each team. Each invitational that a school attends also charges a fee. These vary. Coaches estimate that yearly materials and equipment costs run \$400-500. However, if a coach is starting a team, the recommendation is to get a STEM grant or a community sponsor to donate $\$ 1000$ to buy the one-time expense equipment as well as the consumable materials.

Travel expenses are the real wild card in planning a budget. This is because it depends upon school location and proximity to other schools holding tournaments. As one coach pointed out, if you are a school in a large metro area with a lot of other schools also competing and all holding invitationals, then you don't have to travel very far to get a lot of practice. Your travel expenses will be low compared to a school that has to travel halfway across a state to attend the
closest tournament. If a school gets to travel to Nationals, that is another level of travel expense. Again, depending on location of school, it may include air fare.

Several coaches mentioned that holding an invitational at their school helped them to raise money so that they could afford travel to other tournaments. Additionally, they run concession stands at sports events and I saw a concession stand being run at an invitational I attended. Anything that the school allows the team to do to raise money should be considered because money is given as the greatest limiting factor to a team.

Invitationals allow schools to take more than their 15 -member official team to competitions. "We kind of used that to not only get them all to practice but also to determine our final team - who would be on the final team," explained Sandra in Appendix P.

As Robert stated in Appendix O previously, before Covid-19 his school competed in 8-10 invitationals each year and would travel as far as two states away for some of them. The 2021 2022 competitive year they were only able to find three invitationals and only one was in person. They won two of them. Robert says that in those two wins they were able to demonstrate to the students that the win did not come because they had a superstar in one event. "We had decent performance in every event, and it was because we did every single event and had a decent performance that it's the cumulative score of everybody participating is why we won." He emphasizes that the teams that came in second place did better than them in several events, but they did not participate in all the events. That was one of the decisions the team made at the beginning of the year because it was something Robert learned from the previous coaches. "If you just show up and you do something, you may not be world class in it, but [you are] getting three- or four-point placement instead of a 15 non-participant points." He says that made the
difference between them and the second-place team. He says he thinks it is important that the students understand it is a team effort. "That's why we win."

## Recruitment.

In discussing team recruitment at the beginning of school and team structure, Scott (Appendix Q) says, "If I have 30 middle school kids show up, then we'll immediately pay that second entry for regionals and state and we'll let it be known to the kids that we're entering two teams." This is one of the newer benefits that he and other coaches in his state pushed to have enacted. The state now allows two teams per school to be entered into the regional competition. He says that letting them know up front that there is a spot for them on a team keeps them encouraged and interested.

Some coaches expressed difficulty in recruiting enough students to have a 15-member team. Strategies presented included arranging with teachers to allow the coach to come into classes and give a brief presentation about Science Olympiad and invite students to an organizational meeting. Several coaches emphasized that having snacks available to students at this first meeting as well as at subsequent weekly meetings was important in participant retention. One recommendation for that first meeting is to have a building activity that they can all do together to get a feel for what it is like. Have returning members assist the new prospects so that they have guidance and immediately feel part of the group. Coaches also shared that having returning team members recruit students at the start of the new school year provided an effective means of adding quality members to the team because students often recruited students they viewed as desirable event partners or who they felt would be good at specific events.

Having a winning team the previous year seems to make recruiting new members easier for some teams. Coaches with teams that had a winning tradition indicated less trouble in recruiting enough members to have a full team. This seemed to not depend directly on school
size in that a small school with a winning tradition could have enough interest to field two teams. The multiple team concept is one strategy that schools use when there are more than 15 interested students. The second team is often used as a place for the alternates to compete. This way less experienced team members have an opportunity to build their skills for future competitions. Most coaches explained that alternates were often the ones competing at State because the members of the main team had a conflict. Proms being a common conflict named along with music and band competitions. Alternates who are not involved in a music competition or are younger underclassmen than would be affected by a prom, get moved into the vacant slots on the main team. Coaches fortunate enough to start the year off with multiple teams still commented that they might not get to State with a full team. This emphasizes the role time conflicts play in this activity as well as the importance of recruiting many students into the activity.

## Publicity.

Being a successful team is meaningless for recruitment purposes if no one knows about it. Some of the challenges mentioned in getting the team publicity is the lack of local newspapers because many small towns have lost their local papers. Some schools also have discontinued the printing of school newspapers. In both cases, the newspapers have sometimes been replaced with some type of digital format such as a community or school webpage for the publishing of local events and articles of interest. The church affiliated schools utilize their church bulletins to let the community know about their school activities. Even when a printed newspaper exists in a community, there may not be a reporter assigned to cover school activities other than sports. Therefore, coaches need to write and submit their own articles and pictures about the team's Science Olympiad achievements.

## Team structuring and building.

Methods for structuring membership on teams where more than 15 students are involved varies from school to school. Team structure starts with recruitment. The more participants, the more likely the coach can put together a team that can successfully cover all 23 events. As previously stated, there is a bit of a cycle that develops. If a team is successful, then it is easier to recruit students for the next year. So, success breeds success. A tradition of success can even seem to keep a team going a year or two after a strong coach retires or leaves. As Laura (Appendix K ) discusses, though, the coach really must drive the team with enthusiasm to maintain student motivation.

The coaches all note that students on the team develop a camaraderie. Some coaches recommend actively building this by having the students meet for note printing or note binder making parties, build parties, or study parties all with food. These serve to keep students working on their events and build that sense of team or family. Holding mini tournaments serves to do the same. Laura describes in Appendix K that she sends out motivational cards to build excitement about upcoming tournaments or remind them that if they work hard, they could have a special trip to Nationals. She said she used Disney themed cards the year the Nationals were in Florida hinting that they could go if they worked. They went. She says that the kids must know that you want it for them and that you are as excited about it as they are.

Most of the coaches recommend letting the students run as much of the team as possible. Some of the coaches acknowledge that student personalities can be an issue. Coaches report that pairings do not always work out, but for the most part, it seems the students come to understandings and mange to cooperate. One strategy some coaches gave as an example is that some partners divided the event subject matter into sub-topics and each focused on their own area. Learning to delegate responsibility is a valuable workplace skill for the future. In addition
to helping overcome leadership conflicts, this strategy also benefitted the students in the testing events.

Leslie (Appendix L) says that since they are in high school, she lets them pair themselves for the events. "I think by the time they get to that point they know who they're gonna work with the best." She says she only puts pairs together if a student comes to her and says, "I want to do this event, but I don't really have anybody to do it with me." Then she considers who she thinks might be good and asks them if they will give it a try. Matt has his project manager that he lets handle the pairings. Again, keeping that organizational aspect student run.

Throughout the year, the pairs and trios are meeting with their coaches on different nights after school, but Laura (Appendix K) feels it is important for the whole team to come together. She says that they do team building at the beginning of the year and at the end. "We do team building partly because it allows each group to know what the other groups are doing, and the kids love seeing the building. Laura calls the builds "target shoots". She says, "You know, one day it works perfectly and the next day it won't even go. So, you don't know what's gonna happen with that, but they love watching that. They have two mandatory practices. One practice is before the regional meets and one is before state. "We spend from about 9:00 to 1:30 and we eat lunch together, but they all work and . . help each other study." For the afterschool practices the coaches will sometimes bring a cheap pizza or a snack because the students have been at school all day and may not get home until 6:00. "...our coaches are good at bringing in food for them. If it's not a snack, we get Caesar pizza. They're only five bucks, you know, we can afford that...". She says that helps the kids get closer because they stand and talk to each other while they eat.

Beth explains in Appendix I how letting students choose a partner, especially in the situation of a substitute and when it is a building event, is important. "These two people built it, and they have more ownership in it." However, things happen, and one partner may not be able to attend an event. That is when she hears the remaining partner asking, "Oh, okay, can so and so work with me on this event?" She says then she lets them figure it out. "These kids are typically the kids in the college-bound classes." She says that they probably have all the AP classes together as well as interacting in Science Olympiad. "So, they know each other's strengths."

Trips are recommended as great team builders. When Laura in Appendix K was allowed to stay overnight on a trip, she took the team to an invitational in State D. She says it was great to go there on Friday night, get up on Saturday morning for the tournament, have dinner, and then come home. Now that she cannot stay the night, she takes her team across the state to a different invitational. They must leave at 4:00 in the morning and will not get home until after midnight, but she feels it is important that they have some time after the tournament. She takes them to a place where they can go through a buffet and get tokens so that they can play games after they eat.

Sophia (Appendix P) is very careful to call her group a team to convey the competitive nature of what they do over just the social interaction people expect with a club. This is something that a new coach needs to take into consideration. What are the school rules about a club versus a team? At some schools only teams can compete, and clubs cannot or there may be rules about who can fundraise and how money can be used that is different between clubs and teams. There may also be differences regarding the ability to travel between the two
designations. It is important for the coach to know the rules and get the right designation from the beginning to avoid restrictions and issues on activities in the future.

As stated earlier, Mark in Appendix M believes that students need goals, but sometimes it is hard to get students to set those goals without some prodding and that is part of the coach's job. He says that once they figure out that they can do something, then they start doing a little bit more on their own. "Then you poke them down the road and say, 'What about this?"" Sometimes the student will say something a little unusual. Then he asks, "Well, what do you know about that? How is that interesting for you?" That might become something that they go home and research that night. He says, "It takes time. It takes some questioning. I mean, artful questioning from some people to challenge a kid into who they become." He finds it is a challenging part of being a teacher to be one step ahead of the students and to "find out where they're headed and ask them some more questions." He says that it is "all those little things they just kind of delve into and they become their own person."

All the coaches agree that small schools are at a disadvantage, especially if they are rural and somewhat distant from the larger metro areas of the state. First, a small school has a smaller student population from which to recruit a team. It is critical that a team that wants to compete well must cover all 23 events. That can be difficult even with a full team of 15, but worse with a team of seven or eight. If a student does nothing more than go in and sign their name on a test, at least the team is not penalized for not competing. This is a tactic recommended by coaches who consistently take teams to State. One coach pointed out that sometimes students surprise themselves and do decent enough with their basic classroom knowledge on the test to earn the team some points. Anything is less damaging than taking the penalty.

Community support is important for all teams, but it is critical for small schools. A team really needs to have expert mentors. The more isolated a community is the more difficult it may be to find the variety of expertise needed, but the team must have the support of those who are in the community. Volunteers must be recruited. Those coaches who indicated they had an adequate number of parent volunteers as well as expert mentors for events stated that they directly asked those individuals to be involved. Coaches who said they put out blanket requests and waited to see who responded indicated that they only had a few volunteers each year. These coaches indicated that they would like more help and especially wanted expert mentors. The solution is you have to go out and find those people and ask them to be part of the program.

As a volunteer, Beth (Appendix I) understands the importance of getting people involved and shares a similar perspective with Laura in Appendix K on the importance of many coaches and other volunteers to enable the team to perform to the best of its potential. "I have awesome parents," she exclaims at one point. It is important for a coach to communicate to the parents that they do not need to be formally trained in science or an expert in any of the event topics to help. Helping students with organizational skills in building binders, helping with tool usage for builds, coordinating transportation, manning the home room at tournaments, and organizing food and snacks at tournaments are some ways outside of event mentorship that parents can help contribute to the success of the team and reduce stress on the coach.

## Recommendations for Future Research

For future study, the researcher would like to gather the student data for their experiences. Originally students were to be a part of this study. Several schools were recruited, and questionnaires were sent. Ultimately, only one school returned completed questionnaires from about half of their team. Coaches from the recruited schools stated that students filled out the questionnaires at meetings but would not return the parental permission slips. Therefore, the
student portion of this study was abandoned. Reading of the few student questionnaires that were returned indicated that the students verify much of what the coaches say the student experiences are like. However, the few questionnaires returned gave some indication of a wider variety of experiences than the coaches conveyed in the interviews. It would be interesting to explore these experiences and is an area in which only a few studies have been done.

A specific area of the student experience that would be enlightening is that of competition pressure. This was downplayed in the interviews as something handled by mentor and team support. An example of this could be Scott in Appendix Q . He is competitive and enjoys competition. That also seems to transfer to his teams. The school has a tradition of winning or placing highly and so there is an expectation of that type of continuous success. This tradition means that everyone involved (student, coaches, and administration) starts the year with an understanding of the dedication and work that will be involved. Therefore, it is assumed the students entering are aware of the expectations while coaches and administration are aware of the necessary support required. Does this really work for the student as anticipated by the supporting adults? How much competition stress is self-imposed by the competitive nature of the individual student and how much is placed there (maybe) unintentionally by the other team members and/or the coach due to the winning tradition?

The sports analogy to SO teams is strong in some ways. A study into the ways in which SO coaches and sports coaches view their teams would be interesting. Several of the coaches involved in this study also coached a sport. The sport that was suggested as being most similar to SO was track in the way there were multiple events and in how the meets (notice that same terminology) were structured. This suggests a comparison between SO teams and track teams could be enlightening.

A long-term study to investigate the impact Science Olympiad has on influencing female students to consider STEM careers during middle school and follow through to college graduation in comparison to female students who participated in other STEM competitions and those who did not participate in any extracurricular STEM activity could give insight as to whether Science Olympiad (and possibly other competitions) play an important role in the development of female scientists. This is of additional interest because attracting more female students to STEM careers is a stated goal of Science Olympiad. Scott in Appendix Q feels that the format of the Science Olympiad is more attractive to female participants than some of the other science competitions. It would be interesting to see if there is evidence to support this idea.

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Science Olympiad wiki Detector Building https://scioly.org/wiki/index.php/Detector_Building
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Science Olympiad wiki Food Science https://scioly.org/wiki/index.php/Food_Science
Science Olympiad wiki Forensics https://scioly.org/wiki/index.php/Forensics
Science Olympiad wiki Herpetology https://scioly.org/wiki/index.php/Herpetology
Science Olympiad wiki MagLev https://scioly.org/wiki/index.php/MagLev
Science Olympiad wiki Meteorology https://scioly.org/wiki/index.php/Meteorology
Science Olympiad wiki Ornithology https://scioly.org/wiki/index.php/OrnithologyScience Olympiad wiki Ping Pong Parachute. https://scioly.org/wiki/index.php/Ping_Pong_Parachute

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## Appendix A: Coach Questionnaire

## Coach Questionnaire

Number of years teaching: $\qquad$ Gender: $\qquad$
Number of years involved in Science Olympiad (SO) including the current year: $\qquad$

1. How did you first become involved in SO. Please include a discussion of what you found appealing about SO that made you want to be involved.
a. If this is your first year, will you continue your involvement? Please explain why or why not.
b. If you have been involved for more than one year, please describe the aspects of SO that have maintained your interest.
2. Discuss ways in which you see your students benefiting from participation in SO. This can include, but is not limited to, career related, academics, personal growth, social, etc. Give specific examples if possible.
3. Name any drawbacks you see students may experience as part of SO participation. This can include, but is not limited to, academics, personal growth, social, familial, etc. Give specific examples if possible.
4. Explain the benefits you as a coach experience from participating in SO. This might include career related, personal, social, emotional, etc. Please give specific examples.
5. Talk about the drawbacks you as a coach experience from participating in SO. This can include, but is not limited to, career related, personal, emotional, familial, social, etc. Give specific examples if possible.
6. How do you think that SO participation impacts student knowledge? This might include science knowledge, knowledge in other academic areas, life skills, etc.
7. Describe the amount and type of support you receive from your school administration. This might include emotional support, financial support, volunteering, etc.
8. Describe the amount and type of support you receive from other teachers in your school. This might include emotional support, letting participants out of class for practice, helping students in making up missed assignments, volunteering, etc.
9. Describe the amount and type of support you receive from participants' parents. This can include, but is not limited to, emotional support, financial support, volunteering, etc.

# Appendix B: Coach Follow-up Interview Questions 

## Coach Follow-up Interview Questions

(The interviews will be semi-structured with questions like those listed below being asked depending upon participant responses on the original questionnaire. Follow-up questions will vary by participant.)

1) What subjects do you teach at your school?
2) Which division(s) do you currently coach?

What other divisions have you coached?
3) Have you coached at more than one school?
a. If so, how do your experiences between the schools compare?
4) From your experiences, describe ay factors you have found critical for the success of a team.
5) How many teams do you currently coach?
6) Do you have an assistant coach?
7) Describe what you consider emotional support from your administration/coworkers.
8) How important is it for you to interact with other Science Olympiad coaches?
9) How many hours per week on average do you expect a student to spend on Science Olympiad?
10) What kind of process do you have for students to become members of your team(s)?
11) How do you determine which events a student participates in?
12) In what ways do students show that they are enjoying the SO experience?
13) Can you describe for me specific examples of knowledge that has increased and what things indicate to you that certain knowledge has increased?
14) How often do you feel you have coached a successful team?
15) How much publicity does your team get at your school? In your community?
16) Do you get a stipend? How much does that help in your coaching efforts?
17) How do you feel Science Olympiad participation has impacted you personally?
18) How do you feel Science Olympiad participation has impacted you professionally?

## Appendix C: ISEF Categories

ISEF Categories

Animal Sciences (ANIM)<br>Behavioral and Social Sciences (BEHA)<br>Biochemistry (BCHM)<br>Biomedical and Health Sciences (BMED)<br>Biomedical Engineering (ENBM)<br>Cellular and Molecular Biology (CELL)<br>Chemistry (CHEM)<br>Computational Biology and Bioinformatics (CBIO)<br>Earth and Environmental Sciences (EAEV)<br>Embedded Systems (EBED)<br>Energy: Sustainable Materials and Design (EGSD)<br>Engineering Technology: Statics and Dynamics (ETSD)<br>Environmental Engineering (ENEV)<br>Materials Science (MATS)<br>Mathematics (MATH)<br>Microbiology (MCRO)<br>Physics and Astronomy (PHYS)<br>Plant Sciences (PLNT)<br>Robotics and Intelligent Machines (ROBO)<br>Systems Software (SOFT)<br>Translational Medical Science (TMED)

## Appendix D: Science Olympiad Events Division B

| Science Olympiad Events Since 2008 - Division B |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Air Trajectory |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |
| Amphibians \& Reptiles | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Anatomy | X | X | X | X | X | X | X | X | X | X |  |  |  |  |  |  |
| Anatomy \& Physiology |  |  |  |  |  |  |  |  |  |  | X | X |  | X | X | X |
| Awesome Aquifers |  |  |  | X | X |  |  |  |  |  |  |  |  |  |  |  |
| Balloon Launch Glider | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Battery Buggy |  |  | X | X |  |  |  |  |  |  | X | X |  |  |  |  |
| Bio-Process Lab | X | X | X |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Boomilever |  |  |  |  |  | X | X |  |  |  |  | X |  | X |  |  |
| Botany |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |
| Bottle Rockets |  |  |  | X | X |  |  | X | X | X |  |  |  |  |  |  |
| Bridge |  |  |  |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Can't Judge a Powder |  |  | X | X |  |  | X | X |  |  |  |  |  |  |  | X |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Chiropterology |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Circuit Lab |  |  |  |  |  |  |  |  |  |  |  | X |  | X |  |  |
| Code Busters |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |
| Compute This |  | X | X | X | X |  |  |  |  |  |  |  |  |  |  |  |
| Crave the Wave | X | X |  |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Crime Busters |  |  |  | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Density Lab |  |  |  |  |  |  |  |  |  |  |  | X |  | X |  |  |
| Digital Structures |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  |
| Disease Detective | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Dynamic Planet |  | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Ecology | X | X | X | X |  |  |  |  |  | X | X |  |  |  |  |  |
| Elastic Launch Glider |  |  |  |  |  |  |  | X | X |  |  | X |  | X |  |  |
| Elevated Bridge |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Entomology |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Environmental Chemistry |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Experimental Design |  | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Fast Facts |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  | X |
| Flight |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |
| Food Science | X |  |  |  | X | X |  |  | X | X |  |  |  |  | X |  |
| Forestry |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  | X |
| Fossils |  | X | X | X |  |  |  | X | X |  |  | X |  | X |  |  |
| Game On |  |  |  |  |  |  |  |  |  |  |  | X |  | X |  |  |
| Green Generation |  |  |  |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Helicopters |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  |
| Heredity |  |  |  |  |  | X | X |  |  |  |  | X |  | X |  |  |
| Herpetology |  |  |  |  |  |  |  |  |  |  | X | X |  | X |  |  |
| Hovercraft |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |
| Invasive Species |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |
| Junkyard Challenge |  |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |
| Keep the Heat |  |  |  |  | X | X |  |  |  |  | X |  |  |  |  |  |
| Machines |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Meteorology | X |  | X | X | X | X | X | X | X | X |  | X |  | X | X | X |
| Meteorology-Climate |  | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Metric Mastery | X |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  |
| Microbe Mission |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Mission Possible |  |  |  |  | X | X |  |  | X | X |  |  |  | X | X |  |
| Mousetrap Vehicle |  |  |  |  | X | X |  |  |  |  |  |  |  | X | X |  |
| Mystery Architecture | X |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |
| Oceanography | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Optics |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Ornithology |  |  | X | X |  |  |  |  |  |  |  |  |  | X | X |  |
| Parasitology |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |
| Pentathlon |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Phys. Sci. Lab Wind Power |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Picture This |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |
| Ping Pong Parachute |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Potions \& Poisons |  |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |
| Reach for the Stars | X | X |  |  | X | X |  |  | X | X |  |  |  | X |  |  |
| Road Scholar | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Robo-Cross | X | X |  |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Rocks \& Minerals | X |  |  |  | X | X | X |  |  | X | X |  |  |  | X | X |
| Roller Coaster |  |  |  |  |  |  |  |  |  |  | X | X |  |  |  | X |
| Rotor Egg Drop |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  |
| Science Crime <br> Busters | X | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Science Quiz Bowl |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |
| Science Word | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Scrambler | X | X |  |  |  |  |  |  | X | X |  |  |  |  |  |  |
| Shock Value |  |  | X | X |  | X | X |  |  |  |  |  |  |  |  |  |
| Simple Machines | X |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Solar System |  |  | X | X |  |  | X | X |  |  | X | X |  |  | X | X |
| Sounds of Music |  |  |  |  |  | X | X |  |  |  |  |  |  |  | X | X |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Storm the Castle |  |  |  | X | X |  |  |  |  |  |  |  |  |  | X | X |
| Thermodynamics |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |
| Tower <br> Building/Towers | X |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Trajectory | X | X | X |  |  |  |  |  |  |  |  | X |  | X |  |  |
| Water Quality |  |  |  |  | X | X | X |  |  |  |  |  |  |  |  |  |
| Wheeled Vehicles |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  | X |
| Wind Power |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |
| Wright Stuff |  | X | X |  |  |  |  |  |  | X | X |  |  | X |  |  |
| Wright Stuff Electric |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |
| Write It/CAD it |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  |
| Write It/Do It | X | X | X | X | x | X | X | X | X | X | X | X |  | X |  | X |

## Appendix E: Science Olympiad Events Division C

| Science Olympiad Events Since 2008 - Division C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Air Trajectory |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |
| Anatomy \& Physiology |  |  | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Astronomy | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Boomilever | X |  |  |  |  | X | X |  |  |  |  | X |  | X |  |  |
| Botany |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |
| Bridge |  |  |  |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Bungee Drop |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Cell Biology | X | X | X |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Chem Lab | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Chiropterlogy |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |
| Circuit Lab | X |  |  |  |  | X | X |  |  |  |  | X |  | X |  |  |
| Codebusters |  |  |  |  |  |  |  |  |  |  |  | X |  | X | X | X |
| Compound Machines |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Cybersecurity |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Designer Genes |  |  |  |  |  | X | X |  |  |  |  | X |  | X |  |  |
| Detector Building |  |  |  |  |  |  |  |  |  |  |  | X |  | X | X | X |
| Digital Structures |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  |
| Disease Detectives | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Dynamic Planet |  | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Ecology | X | X | X | X |  |  |  |  |  | X | X |  |  |  |  |  |
| Egg-O-Naut |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Elastic Launched Glider |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  |
| Electric Vehicle | X | X |  |  |  |  |  |  | X | X |  |  |  |  |  |  |
| Elevated Bridge |  | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Entomology |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |
| Environmental Chemistry |  | X | X |  |  |  |  |  |  |  |  | X |  |  | X | X |
| Experimental Design | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Fermi Questions | X |  |  |  | X | X |  |  |  |  | X | X |  |  |  | X |
| Five Star Science | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
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| Flight |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |
| Food Science | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Forensics | X |  | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
| Forestry |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  | X |
| Fossils |  | X | X | X |  |  |  | X |  |  |  | X |  | X |  |  |
| Game On |  |  |  |  |  |  |  |  | X | X | X |  |  |  |  |  |
| GeoLogic Mapping |  |  |  |  |  |  | X | X | X |  |  | X |  | X |  |  |
| Gravity Vehicle |  |  |  |  | X | X |  |  |  |  |  |  |  | X | X |  |
| Green Generation |  |  |  |  |  |  |  | X | X |  |  |  |  |  | X | X |
| Health Science | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Helicopters |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Herpetology | X | X |  |  |  |  |  |  |  |  | X | X |  |  |  |  |
| Hovercraft |  |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |
| Hydrogeology |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |
| Invasive Species |  |  |  |  |  |  |  |  | X | X |  |  |  |  |  |  |
| It's About Time |  | X | X |  |  |  |  | X | X |  |  |  |  |  | X | X |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Junkyard Challenge |  | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Machines |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |  |
| MagLev |  |  |  |  |  | X | X |  |  |  |  |  |  |  |  |  |
| Materials Science |  |  |  |  |  | X | X |  |  | X | X |  |  |  |  |  |
| Microbe Mission |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Mission Possible |  |  | X | X |  |  | X | X |  |  | X | X |  |  |  |  |
| Mousetrap Vehicle |  |  | X | X |  |  |  |  |  |  | X | X |  |  |  |  |
| Oceanography | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Optics |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Ornithology |  |  | X | X |  |  |  |  |  |  |  |  |  | X | X |  |
| Physics Lab | X | X | X |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Physics Lab - Wind Power |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Picture This |  | X | X |  |  |  |  |  |  |  |  | X |  |  |  |  |
| Ping Pong Parachute |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X |  |
| Protein Modeling |  |  |  | X | X |  |  | X | X |  |  |  |  | X |  |  |

## $\bar{\pi}$

|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Remote Sensing | X | X | X | X | X | X |  |  |  | X | X |  |  |  | X | X |
| Robot Arm |  |  |  |  | X | X |  |  | X | X |  |  |  |  |  |  |
| Robot Ramble | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rocks \& Minerals | X |  |  |  | X | X | X |  |  | X | X |  |  |  | X | X |
| Scrambler |  |  |  |  |  |  | X | X |  |  |  |  |  |  |  | X |
| Sounds of Music | X |  |  | X | X |  |  |  |  |  |  | X |  | X |  |  |
| Sumobots |  |  |  | X |  |  |  |  |  |  |  |  |  |  |  |  |
| Technical Problem Solving |  | X | X | X | X | X | X | X |  |  |  |  |  |  |  |  |
| Thermodynamics |  |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |
| Towers |  |  |  | X | X |  |  |  |  | X | X |  |  |  |  |  |
| Trajectory |  | X | X |  |  |  |  |  |  |  |  |  |  |  | X | X |
| Water Quality |  |  |  |  | X | X | X |  |  |  |  | X |  | X |  |  |
| WiFi Lab |  |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |
| Wind Power |  |  |  | X |  |  |  |  | X | X |  |  |  |  |  |  |
| Wright Stuff | X |  |  |  |  |  |  | X | X |  |  | X |  | X | X |  |


|  | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
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| Write It/CAD It |  |  |  |  |  |  |  |  |  |  |  |  |  | X | X |  |
| Write It/Do It | X | X | X | X | X | X | X | X | X | X | X | X |  | X | X | X |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

# Appendix F: Introductory Coaches Letter 

Introductory Coaches Letter

## RE: Request for participation in Science Olympiad Study

## Dear :

My name is JulieAnna Rohde, a doctoral candidate in the Science Education program working with the supervision of Dr. William McComas at the University of Arkansas in Fayetteville. I am working on my dissertation which will focus on The Science Olympiad. This study focuses on uncovering what attracts coaches to participate in Science Olympiad and what makes them want to continue to participate each year.
It is fantastic that you and your school provide students with this opportunity to explore STEM fields. I hope that you as the team Coach will choose to participate by completing a nine-item Coach's questionnaire. If you choose to participate, the questionnaire process should take approximately 20 minutes. Please find a copy of this document and a consent form attached.
Any written results will discuss group findings and will not include information that will identify you or your school. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research. Should this study be published, each school will be assigned an alias for any discussion or comparisons of demographics. Your school will only be known for its demographics. No costs will be incurred by either your school or you as a participant.
Your participation in this study will be greatly appreciated. I would be happy to answer any questions or concerns that you may have. You may contact me at my email address:
jdrr2d2@gmail.com.
There has been very little research done on this aspect of Science Olympiad so participation is important. If you agree to participate, please find attached to this email a consent form and a questionnaire to complete. Send completed forms to jdrr2d2@gmail.com. I look forward to reading about your experiences in Science Olympiad!
Sincerely,

JulieAnna Rohde, MSMSE, University of Arkansas

Attachments

## Appendix G: Anne's Science Olympiad Experiences

## Introduction

Anne began her Science Olympiad journey as a student participant and returned as an adult volunteer to eventually find her way to teaching and coaching at a private school in State B. Demographic information on Anne's school is difficult to obtain because it is a private school that did not show on a search of the NCES website. Data sources for private schools that might have listed information required a subscription to access their information. In follow-up questions, Anne did not suggest any changes to the following information taken from the school website. The school website states that the school is in a metropolitan area and recruits from an area covering 78 zip codes. The campus of the school itself sits on both sides of a state line and students from both states attend. According to the school website, there are approximately 1,200 students enrolled ranging from a pre-school program at age 2 and going through $12^{\text {th }}$ grade. The school awarded $\$ 3$ million dollars in need-based financial aid to approximately $25 \%$ of the student body in the 2021-2022 school year.

## History of involvement in Science Olympiad

Anne became involved in Science Olympiad initially as a sophomore in high school when her parents suggested to her biology teacher to recruit her for the team. She had wanted to participate in Science Olympiad in middle school, but her parents had wanted her to do Math Counts. She did not like the math competition, so her parents thought to help her get back to her original desire with Science Olympiad. The SO team was mostly juniors and seniors and she felt like they knew so much more than she because they had done all these science classes. "So, when I went to my first competition - just kind of to try it out- and I came home with a ribbon from that thing and like, Wow! I can actually do this!" She says it was because even though the older students had more science education, none of them knew anything about reptiles and
amphibians. (Amphibians and Reptiles is an event that has since rotated off the current offerings. It was last offered as a middle school (Class B) event and has been more recently replaced in both Class B and C competition with the Herpetology event. For short event descriptions of Division B events, see Appendix T. Short descriptions of Division C events are given in Appendix U). This type of variety in events is one of the positive aspects she sees:

That's kind of one of those things that's great about Science Olympiad is sure there are events for which your coursework really gets you well prepared, but there are others which you just have to go out and learn on your own and so it really gives a new person a fighting chance to get involved.

Anne started teaching because she wanted to coach Science Olympiad. She was living in a different state at that time and did some research on which of the private schools around her had the best Science Olympiad track record. She applied, was hired, and helped coach that team to second place in the state that year. Then her alma mater found out she was teaching and asked her to come back home and help coach their team. She came back and has been teaching and coaching Science Olympiad there ever since. Giving her a total of 14 years coaching and 3 years as a student participant.

## Perceived Benefits of Science Olympiad Involvement Personal benefits.

The main benefits that Anne mentions from both the past and the present all have to do with friendships and fun. The friendships started for her in high school with her teammates and that will be further explored later as part of student benefits. As a coach she says her friendships have gone beyond what they were as a student. Because she teaches at a private school and is not part of a district, Science Olympiad is the way she gets to meet the other science teachers in
her city. She says they see each other at tournaments and exchange information, phone numbers, ideas, and exchange strategies. "I feel like I've made some really cool friends just as a coach."

In spite of some rivalries, the coaches in Anne's state are willing to help each other. She explains that this may be due to her state being one of the first states to get on board with Science Olympiad. To get the program going, the first schools had to recruit other schools so there would be enough schools to have tournaments. "There were a few coaches locally who went out and recruited other schools to come into the fold." She says that they held workshops and mentored new teachers. The state has lost teams in the past few years and the new state director is trying to revitalize the state by trying to connect new coaches with more experienced ones so that the new coaches feel supported. "Sure, we have some rivals, but they're pretty friendly rivalries." She says her team gets beat frequently by their main rival across the state from them, but she and their head coach exchange thoughts and practice tests back and forth. She admits that rivalries used to be less fierce when the state could send two teams to Nationals.

Rivalries also seem to fade when coaches have talked about their issues with each other and shared strategies because each coach begins to feel a small stake in the other coach's team. She mentions again about the situation between her and her main rival coach. "When we come in first and the other ones come in second, we actually feel bad because it's like looking at our own kids not getting to go." She sees a lot of empathy and respect in her state system. "I'd like to think we all get along pretty well."

Getting to work with other faculty as her assistant coaches and form friendships with them is also a benefit. "We become better friends because we're getting to hang out more outside of school." Friendships with students are also an enduring aspect of her Science Olympiad experience. Like with the other coaches she thinks the outside of class setting is
beneficial. "It's just such a nice thing because you get to know kids in such a different capacity outside the classroom." She stays in touch with many of the students she has taught. "I've mentored a few of them in their first year of teaching. That's really been amazing." Some of her former students routinely return to help run events at the school invitational. She says she and her former teammates would often come back to do that too when they were in grad school. "For me, it's just a lot of like shared community warmth and this is that thing I contribute because it's that thing I know how to do."

Anne does not see Science Olympiad furthering her career more than it already has. She admits that she and others she knows have considered leaving the teaching profession. "I thought for a long time that if I were to leave this, I would volunteer with the state organization." She thinks she might like to be regional director but thinks that being state director would be too hard. Science Olympiad is not viewed by her as a steppingstone to anywhere else in her teaching career. "It was always something I'd wanted to do because I grew up with it." Anne replaced her former coach when that coach retired. That former coach still volunteers to run events at regional and state tournaments. When asked why she said, "I think once you're hooked on it, it's hard to get out."

Having these friendships are fun for Anne and she also finds fun in some other aspects of Science Olympiad. "It's really fun to see these kids fall in love with something that they wouldn't have otherwise met." She loves it when the students come back from an event and want to tell her all about it. "What I love is when like something goes wrong and then they tell me like how they rigged their things so it can still work at all." Sometimes the students talk to her about how the test was not as expected and so they remembered something they thought was related to the question and started writing about that. "I get to see my kids at their most clever
and kind of like their giddiest." She describes the environment of her private school as an "academic meat grinder". Therefore, she likes to see her students have an opportunity to be playful in their learning. She says she gets a nostalgic feeling when she watches her students doing the same things she did. The lifelong memories she formed from those tournament trips she says were the best thing ever and will be further explored under the heading of student benefits.

Anne does not receive a stipend. "The benefits for me are not financial." Her school expects each teacher to take on several extra duties beyond classroom teaching. She claims that Science Olympiad keeps her required duty requirement interesting. She would rather be doing Science Olympiad than watching study hall or "doing something that I'm less comfortable with like chaperoning a bunch of school dances or something like that". Mentoring Science Olympiad gives her more satisfaction than the other options would. "It's just I think you get a passion for something and it's just so fun to communicate that on - I think it's very special."

## Perceived student benefits.

As a Science Olympiad participant Anne benefitted from what she calls the "inclusivity of format" provided by the Science Olympiad events. As a coach, she continues to see this as a benefit to students. She contrasts it to robotics which she thinks is a great competition, but it only appeals to students with that interest. "If a student is interested in biology or in medicine, you need somewhere else for them to kind of explore that knowledge." Many students come into her high school from other schools. With Science Olympiad it does not matter what age they join, whether they have done Science Olympiad before, how many science classes they have had, or anything about their personal background. Younger students can learn an event and contribute just as much as older students. "If they are interested, I can plug them in with something and I think that is really great."

Once students are involved in Science Olympiad, they can build confidence in their scientific ability in one topic and become brave about exploring other topics. Anne does not think that Science Olympiad participation improves test scores or classroom performance directly. She thinks that most of the Science Olympiad participants are just good at course work anyway. Science Olympiad might cause students to improve their organizational skills, but she sees most students bringing those skills to the table to start. Where she sees Science Olympiad impacting the students the most academically is the building of confidence and developing a willingness to challenge themselves. "A lot of it is they just feel empowered to take harder [more advanced] classes." She uses herself as an example. ". . . I wouldn’t have taken physics in high school if I hadn't done Science Olympiad. I was scared to death of that. Now I teach physics." She sees some of her Science Olympiad students doubling in science classes in their junior or senior year because Science Olympiad has given them the confidence to know they can do it.

Part of this confidence comes from the structure of Science Olympiad encouraging students to be self-reliant. "Just the idea early on that you don't need someone else to teach it to you - you can teach yourself - is really ingrained in Science Olympiad and so I think it really promotes independent learning and rewards it." The diversity of the events means there is not always an expert mentor around. Anne gives an example of a student who competed in the robotic arm event. Because she describes herself and the other coaches as being so bad at helping him, he and they could not figure out how to modify one of the approved kits to do what was required by the event rules. The student wound up building a robotic arm from scratch all by himself and, because of his innovativeness, got an internship with NASA. "It really kind of
forces the kids to figure stuff out themselves." The really important thing for her is that the students are doing it. "This is all about seeing kids do crazy stuff."

This "crazy stuff" she refers to is sometimes rather innovative. In addition to a student building from scratch rather than modifying a kit, students may find themselves having to repair with limited materials. When a team arrives at a tournament, that morning they must impound their build and everything that is to be used with it for the competition. Impounding is placing the building project in a restricted area so that no further modifications can be made to it until it is time to compete with it. The impound is at the check-in location and the students are later allowed to get the build out and carry it to the event site just prior to the competition. She recalls an incident where a catapult arm broke as the students were carrying it across campus to the event. They could only fix it with the items they had impounded with it. Afterward they were so excited in telling her, "Oh my gosh! We got the catapult to fire!" She asked them if they were anywhere near the target. "Absolutely not." But they were so excited about the way they had managed to get it to work, and she was very proud of their creativity. Anne explains that they get participation points as part of the competition, so it is much better to try to make the device work than to pull out due to broken equipment. By getting the catapult to the point it could at least fire, they were doing their part to help the team.

Test taking events have a similar parallel in that no matter how much study or research a student does, the test can have everything the student did not study on it because it is almost impossible to know everything about a subject. Anne explains that the winning team on a test might get a $50 \%$. So, it is very different from school where the top student is expected to know $95-100 \%$ of the test. "It gets them used to not knowing most stuff and making sort of educated guesses about a lot of things." She sees a lot of innovation in their test taking as well. "It's, you
know, how well can I come up with some baloney that sort of fits this question based on a little bit of other science knowledge I have?"

This opportunity to try things and make mistakes in a low-risk environment is one of the benefits Anne sees in Science Olympiad. Even though it is a competition, she considers the environment low risk. "Does it matter if we come in second or fourth at a local tournament? No." She thinks it's sometimes better when they do not win because that can be motivating to the students. One thing that keeps it low risk is that anyone can be in Science Olympiad. Some invitationals allow more than 15 students on a team. Anne explains that they let whoever wants to compete and then just count the school's top score in each event. "It's a great way for kids to sort of dip their toe in it." She says that the national organization is starting to discourage that practice which makes it hard for her to keep the program open to anyone. "We want people to try it and get better. We don't necessarily need them all to be future national champions."

Though most of her students are involved in multiple things, Anne feels that keeping Science Olympiad open to all is important because it can provide a student a niche they would not otherwise have in high school. She says that plenty of her students are athletes, but if a student is not athletic and likes to compete, they can still be part of a championship team. She acknowledges that many school programs provide a niche, but not all those programs are competitive, and Science Olympiad provides a lot of different niches with its variety of event topics. She thinks it is a great way for some students to get some respect. She uses an example from her student days and describes a student on her team who was awkward and did not fit in anywhere. She said that he did not know until years later because there was not a diagnosis until then, but he had Asperger's. However, he was so good at his Science Olympiad events that the other team members recognized his value, respected him, and always included him in team social
activities. "There was no way we weren't going to be friends with him - even how awkward we could be sometimes together - because we just so respected what he could do."

Respect for teammates comes out of the realization that you cannot do it alone. She says the students talk to her about their experiences in testing and relates a student saying, "I got in there and I had prepared really hard on my part of the information, but then the test really was a total miss for my topics and my partner had to do almost all of it." In a case like this, the student is very glad that their partner prepared as hard as they did and on different topics. They learn respect for their teammates. She always tries to avoid sending a student into an event alone. She would rather send a student who thinks they know nothing about the topic or who has never been in a testing event because they at least get some experience and see how it works. She says sometimes they find they can help. Anne explains that occasionally a test is too long for one person, so the second person can help by just bubbling in multiple choice questions from the back forward. "They'll pick up some pretty good test taking skills out of this."

Learning that you cannot do it alone and to respect the skills of another person who might be different from you helps a student be open to diversity. "Relying on someone in competition who might have different political views than you or might look different than you are a really great basis for future understanding." Anne acknowledges that sports teams provide a similar exposure, but she thinks Science Olympiad is more multi-level in these experiences. She comments on her own experience as a student and how she made "these friendships studying together, sitting on the bus together for hours". She explains how students are not supposed to know who is on scholarship to the private school and who is not, but students seem to figure it out. So, some members of the team are hanging out with others who are not as privileged. "Kind of gets kids out of their normal social groups." When she was a student, it was rather
public about who was on scholarship. She says that was her source of friends because Science Olympiad was what they had in common. They came into the school and said, "We're all smart. Let's join the Science Olympiad team." They all hung out together and were from diverse backgrounds. She says her parents commented one night that the group of them were like the United Nations because they were so diverse. She still sees this diversity as a characteristic of the Science Olympiad team. "It's a beautiful thing." Additionally, the school does try to recruit a diverse population and they use the fact that they have a successful Science Olympiad team to appeal to some ethnicities. Anne had a Chinese American student interested in joining the team and she confided in Anne, "You know, in the Chinese community around [the city] it really is cool to be in Science Olympiad." Anne did not specify which ones but says some of the other minority communities have similar views. "I love that we're cool."

Anne points out that her best friends were her teammates. "And they weren't even people I was close to before I joined the team. She sees the same pattern with a lot of her students. "Sometimes kids are already friends when they come in, but sometime not - more often not." It comes back to the comments about respect from earlier and the fact that the partners divide up their work. "You start really relying on each other and you really respect what your partner brings to the table." For her, Science Olympiad gave Anne a great way to find other students who were like-minded in some ways but different in other ways. It helped her to get to know upperclassmen because the team has a tradition of pairing upperclassmen with underclassmen. The high school also sends students over to mentor middle school team members. These high school mentors become the leaders of the team and there is an accountability that develops. The mentor cannot let their mentee down and vice versa. "You get a sophomore or a freshman who some senior has been nice to, and they are going to work extra
hard." They do not want to let their leaders down. Friendships can grow out of those mentorships. She says, "My senior year one of my best friends was a ninth grader I met through Science Olympiad". After graduation Anne visited her while she was home on college breaks, and they remained friends all through graduate school.

Travelling together is another aspect of Science Olympiad that is a bonding experience for students. She sees her students bonding together into groups during trips. Anne describes how at the hotel the rooms are all next to each other and they leave the doors open and wander from room to room practicing events. "Those kids really bond over that." She observes students stepping up to the responsibility of looking out for each other. "You see a lot of kindness." Travelling also allows for interaction with other schools. Anne does not often see direct friendships formed with students from other schools during invitationals, but longer trips like state or nationals offer better opportunities for that. If other schools stay at the same hotel, then she sees students from different schools sitting down and talking. She says, "And that's really a cool thing." As a student, she says she always ended up making friends with their rival school when both teams went to nationals.

One thing Anne tries to promote is practicing good citizenship and being helpful to other schools. She uses the example of telling her students that if the rubber band that powers their Wright Stuff airplane breaks on another school's plane and her team has an extra rubber band, loan it to them. The event she refers to here is a C division event where participants make, test, and fly an airplane powered by a twisted rubber band. The goal is to have the airplane with the longest flight time. (Science Olympiad wiki Wright Stuff) "It's not about winning at all costs. It's about winning and being good citizens and being sure other people get a good experience with science, too." Anne explains that when her school holds an invitational or goes to a
tournament, they try to let the other schools know that they are willing to help if the other schools have forgotten anything or need any materials. She says that a lot of why they do that is because they are the local private school, and they know they are privileged. "We"ve got good funding. We've had really good help and how do we give back to the science community?" When she was a student, her school was accused of being "that snobby school". "We are not snobs. We are really nice. How do you project that out into the community?" So, she teaches her team that it is important to "clap really hard for the student who built a better device than you did and congratulate them afterward". She says a lot of it is that most teenagers are a little shy, so she tells them to be brave and go lend a hand. She thinks it is important that students have appreciation for their competitors. "Yes, they're from a school you haven't been to so you don't know what it looks like or what it feels like, but you can see that they're the same as you." Anne says that Science Olympiad prepared her and her teammates for a lot of things in life and career and it especially taught them to work with different people.

Though not all her friend group went into a science field, most of them completed doctorates in their chosen field. Likewise, she has seen some of her students continue into science fields. "If you find you are good at something within science, you find that there are a lot of other different pieces of science you also might be good at." She says she has had a lot of students go into engineering fields. She has a student who is about to graduate with a degree in meteorology. When he was in Science Olympiad, he became so interested in the geosciences events that he said, "When I grow up, I'm going to be a meteorologist." More often, though, she says Science Olympiad just exposes students to science topics beyond what they would get in course offerings and it's fun to see them fall in love with a science topic even if they do not choose to pursue it as a career.

Another advantage to Science Olympiad as a team activity is that it can be somewhat flexible for a student's schedule. She does not demand that the team all get together for meetings to work on things. She allows the partners to schedule when they can get together to individually work or study. Anne gives an example of a student of hers who dances with the city ballet company. "She's in ballet like three hours a day and she can't choose when she's in ballet class, but she can choose when she works on her Science Olympiad stuff." Part of scheduling that Science Olympiad time also depends on when her partner is free. Anne says that fortunately the two live near each other, so it works out well for them to meet without having to drive across the city to work together. She indicates that some of the teammates do drive quite a distance to meet up with each other and practice or work on builds. She also does not demand that they show up to a certain number of competitions to stay on the team. She says being flexible has really helped the team survive. Students also do not miss much school with Science Olympiad participation. They will miss one day if the team qualifies for the state competition and they will miss three days if the team makes it to nationals. That is a lot less than other extracurricular activities.

Anne mentions several times how students gain test taking skills and research skills. Students compile their research for the tests into a binder. The information is condensed into "cheat sheets". These are sheets that students are allowed to bring into some of the testing events. Event sponsors note that students rarely look at their "cheat sheets" because in the process of putting materials into the binder they have absorbed that information. Anne says, "That idea of learning to curate your own resources is very helpful life-long".

A final benefit that Anne sees for students is that they get to build a relationship with their coach. She thinks it is good for the students to see her in a different context from the
classroom. "I think we suddenly become less intimidating." She thinks it allows a teacher to be better able to help guide the students through their high school career and that is a benefit to the student to have that guide. "I think a lot of kids realize you can be an ear for them."

## Workplace and community support.

Anne has the moral support of her school. She feels that a lot of that starts with the administration working to ensure that organizations feel supported. "It's cool that I work at a place that can celebrate its tennis team and celebrate its Science Olympiad team and celebrate its debate team and its performing arts." She says that she and her colleagues have fun cheering each other on and have a lot of mutual respect. There are eight people in the science department. Three are involved in Science Olympiad and the other five are not, but they would help any student who had a Science Olympiad question. When she held her invitational several of the other teachers did offer to help, but she had enough people without them. "I know they would if I asked and we're all good friends, but everybody's so overworked."

Regarding parental support, Anne says, "I have awesome parents." There is a physician who comes in once a week to help both middle school and high school students with the module called Disease Detectives. This is an event for both B and C divisions that focuses on epidemiology. Participants use investigative skills and in division C statistical analysis to answer questions about disease transmission in a population (Science Olympiad wiki Disease Detectives). There is an engineer whose kids have all graduated, but he still comes to help when called. Another parent has a machine shop in his basement and has taught kids how to lathe their own devices. There is a parent who does astronomy as a hobby with her son who is on the high school team and so they both come and help the middle schoolers learn about the solar system. Solar System is a B division event where students compete in pairs to answer questions about planet formation and structure in our solar system and relate that to extrasolar systems. Some
parents also help at tournaments by running events, doing registration, picking up pizzas, running concessions, and tabulating scores.

Even though Anne does not have a class hour for Science Olympiad, the school does provide space for the students to do their builds. "We call it the 'research lab'." She describes it as "a very messy disaster area" about the size of a bedroom that is a shared departmental space. It houses some tools and is connected to a couple of teacher's offices so that students are not in there unsupervised.

Her team does get a bit of recognition. They are showcased by the admission department as a recruiting element. Being advertised as a winning team can create some pressure, but Anne does not feel pressured by her principal to have to continue the tradition at personal cost. He tells her "We know there is no one who's going to try harder than you will. Don't kill yourself at it. We know you need to have a life."

## Perceived Challenges of Science Olympiad Involvement

## Personal and coaching challenges.

If it did happen, Anne would consider being pressured to win a personal drawback as well as a drawback for the students. "You want it to be a place where kids can go and safely make mistakes and learn from there." She does not want her students to have to go find an engineer to help them build a catapult to win. "It's not the learning experience they should have, and we don't want to be in that position of 'Well, that's the only way we could be competitive'." She says her school understands that. "They know we want to keep this kid friendly, and kid focused."

The major challenge Anne experiences and hears other coaches complain about is time. "Kind of the line around our school was that our Science Olympiad program operates through martyrdom of one coach." That had been the historical model, but Anne now has two assistant
coaches. It is still a bit of personal sacrifice in giving up a lot of weekends both for tournaments and practice. The team usually practices a couple of hours every Sunday from October through May.

Anne says that the public school system in her state has been in trouble for the past 20-30 years and teachers have less support. As a teacher at a private school, Anne views this touble mostly from the outside, but can talk about the general attitude she sees from people around her.

The perceived quality of the public education around our city has decreased and was doing so even pre-covid. Our school sits within the boundaries of the [her large city in State B] public school district. That district lost accreditation with the state for multiple years. It has only recently regained accreditation. [State B's] best public schools are crowded around the western suburbs of [the other large city in State B] (mostly adjacent to [a prominent private university]), and there is a big drop off beyond that. The state consistently receives middling rankings (or lower) for public education, and our teaching pay - particularly outside of [the other large city] - tends to be poor, though the state is known for its good retirement benefits.

She thinks that it does not feel like a good idea for a teacher to take on something that requires a lot of extracurricular effort like Science Olympiad when you are already overwhelmed and poorly compensated. Though this is not a personal drawback in her situation, she sees it as a drawback for her colleagues in the public-school setting and could explain why her state has seen a drop in the number of teams. She also acknowledges that since she was in school there has been a growth in other types of academic teams such as robotics and debate that now compete for student participants. Anne does not get directly compensated for coaching as she explained
earlier about the point system. "I would say for the two points it's a much higher workload component than most other things would be, but it's a labor of love."

Covid has presented the most recent challenge. "I know that a lot of my colleagues have been struggling a lot harder since Covid to get their teams motivated." School restrictions made it hard for teams to meet and interest faded. Anne says it is hard to rebuild a team once the interest drops. She had wondered if any extracurricular was going to survive the changes coming out of Covid. "I'll admit, I was sort of having a crisis with the whole thing."

## Perceived student challenges to participation.

The restrictions associated with the pandemic changed Science Olympiad for the students in several ways. Anne says that they were not allowed to come into school to practice on the weekends because that was when the school was deep cleaning. The team could not practice after school because the school wanted to get people off campus as soon as possible. Once a week the school had a long flex period in the middle of the day so they could meet and get some work done. However, all the clubs wanted to use that, so it was hard for students participating in multiple organizations. She was concerned that Science Olympiad would not survive Covid. "It also puts a lot more on the kids to kind of pace themselves and stick with it."

Anne says her team really lucked out the year they competed all virtually by having a senior captain who was very charismatic and really kept the students involved. This year there was a mix of virtual and in person. She says that right now she has a lot of experienced competitors who are good enough to work on their own. Her school has tried to keep things as normal as possible by having in person school with weekly Covid testing students of and personnel, but some other schools have not been able to maintain that consistency, so their teams have struggled. The students that Science Olympiad is at risk of losing are the less experienced who need mentoring. Anne says, "I think kids don't feel as confident trying a science
competition and, when they do, they don't necessarily do as well as maybe their school had done in the past." Though things are moving back to normal, she is still concerned because next year she is graduating a lot of the pre-Covid students who have the experience needed for mentoring. So, she is going to have to rebuild and new members coming onto the team will not be able to benefit from being mentored as much as their predecessors did.

Outside of Covid related hardships, the largest drawback Anne sees for students is time. They have challenges setting up practice times to fit their schedules. She does not have a class period for Science Olympiad, so meetings are outside of school time. The problem with afterschool is that a lot of students do other activities such as sports, theater, or debate that also meet after school. "It's just one more thing in their lives that they're scheduled for and our kids are really over scheduled."

Anne says that approximately $80 \%$ or more of students in the school participate in sports so she has athletes on her team. She specifically mentions soccer as one sport of involvement. Science Olympiad team members are also on the math teams, on the robotics teams, running social justice clubs, and starring in the school musical. She hesitates to label this a drawback:

It's very cool just the different interests they have and a lot of it's what I just call the small school phenomenon or a small enough school that all the kids kind of have to do everything otherwise you just can't get it done.

Science Olympiad differs from some of the other clubs in the frequency of teammate interaction. Anne explains that it is different from something like the French Club where they meet once or twice a year to do an activity. "The kids are talking to each other. They're preparing and having conversations all the time." Again, she wants to consider this more of a benefit, but the fact remains that Science Olympiad takes more time than some of the other clubs.

It was pointed out as a student benefit that Anne tries to be flexible and does not require students to attend a certain number of meetings to stay on the team. The downside to that is that she does not often see the whole team together. "It's not strictly necessary with Science Olympiad to have them all in one place at once. It just helps to be able to do that every once in a while." That flexibility includes not demanding that they attend a certain number of competitions to remain on the team because there are other academic competitions on Saturday. She says soccer is also on Saturday "and you can't miss your soccer game." She says the debate team used to be inflexible about allowing students to miss for things like Science Olympiad, but she has managed to convince them to be more flexible "because we all need to also survive together." She says there are just a lot of conflicts with so many things that the students enjoy doing. "It's just hard for the kids from a scheduling perspective."

Another concern that Anne has about future student participation in Science Olympiad is potential imposed rules from national on how invitationals are run. Currently in her state most invitationals allow a school to bring more than 15 students and whoever wants to compete can. For the competition only the top scores for each school are counted. Anne stated earlier that the national organization is starting to discourage this practice. An easy solution is for Anne to just take multiple teams to the tournaments which is what the other states in this study do. Anne discusses the pros and cons to the multiple team approach.

She explains how the decline in the number of teams in her state led to loss of the state having a second berth at the national competition. If most schools run multiple teams, then that boosts the numbers of registered teams in the state. This sounds good on the surface because it would benefit the students in the state for two schools to be able to each take a team to nationals. However, she explains that there are hidden drawbacks. Anne knows that her school and her
students have advantages over many of the other schools competing. Her team has won annually for a long time. "I think [her school] has to own the fact that we're part of the problem with the attrition." If her students are always taking a bunch of medals, those are medals other teams are not winning. With the current invitational structure of one team per school with unlimited number of students on a team and only the top score per school counting, her school could enter 20 students in an event for example, but only one of them can take a medal. Even if they all were the top 20 scorers in the event, the second-place medal would go to the $21^{\text {st }}$ high score because that student was from a different school. Typically, she says that she might have two or three entries per event and that they could often take the top two or three places. This tournament structure. This leaves opportunities for students from other schools to win medals. Running multiple teams can reduce those opportunities. "We can easily take first and second in a lot of these events and that elbows out other schools that are trying to build their programs or other kids who you want to get excited about science, too." She thinks this will be even more important for teams trying to rebuild and struggling with motivation after Covid. "It's demotivating if you can't win any medals."

## Advice to Those Coaching Science Olympiad

Anne is passionate about encouraging more schools to have a Science Olympiad team. "If you want to start a team, big piece of advice I always give is don't try to do all 23 events." She says a coach's goal the first year is not state championship but to start a program. "Try to get your kids really good on one or two things so they can have that experience of success." She recommends maybe focusing on five events the first year and then maybe seven the second. She says a little bit of success will encourage students to try more. Anne suggests that a new coach choose the categories most like things taught in science classes such as cell biology and experimental design to start. Then build outward from that.

Parental involvement is also important especially for a new program that may not have assistant coaches on board yet. It is important for a coach to communicate to the parents that they do not need to be formally trained in science or an expert in any of the event topics to help. Helping students with organizational skills in building binders, helping with tool usage for builds, coordinating transportation, manning the home room at tournaments, and organizing food and snacks at tournaments are some ways parents can help contribute to the success of the team and reduce stress on the coach.

For a new coach taking over an existing team, her advice varies depending on the role. She says that taking over a program as a head coach has a steep learning curve. She recommends a mentor coach from another school. Even though the team may not be new, a new coach must go through the same processes personally as if they were starting a new team. If there is a nearby school starting a team at the same time, maybe the two could partner. One coach could focus on handling five events and the other coach could focus on a different five events. For a new coach coming in as an assistant coach, she recommends focusing on a few niche places. "Pick three or four events that you can really learn about where you can make a difference for those kids and that's a really good starting place." Regardless of the situation, she gives some universal advice:

Some of this stuff is just so much more approachable than it sounds like it is and especially if you kind of get some collective energy. But it's very hard to do in a vacuum and certainly it's impossible if you try to do too much at once.

## Appendix H: Barbara's Science Olympiad Experiences

## Introduction

Barbara is the science teacher for grades 7-11 at a small school classified as "Rural:
Remote" in State B. In those grades there was a total enrollment of 69 students for the 20202021 school year according to the National Center for Education Statistics (NCES). Thirty-three of the students are eligible for free or reduced lunch.

## History of involvement in Science Olympiad

Barbara started her program at her school as a science club. "We just did those junk box wars and stuff. I would give them supplies and they would make something. It wasn't anything too complicated." She felt that students needed an opportunity for more hands-on than they could get in the classroom, and it might help them become more interested in science. Then she thought it would be fun if the students could do something competitive in science. "I was trying to find something that the kids could do that wasn't just sports because we're a small school." She says that she did not really understand what she was doing when she started. "It was really confusing to read all those rules and all. I didn't understand how difficult some of it was." When she found other coaches, she could talk to about Science Olympiad, it became easier.

## Perceived Benefits of Science Olympiad Involvement Personal benefits.

Upon considering it, Barbara comments that maybe it was she more than the students who wanted something competitive. She says that is probably what has maintained her interest over the years. She likes the challenges she has faced. "For probably six or seven years, I couldn't figure out why schools were going to state and why we just could not score well." She explains that it was particularly hard to medal at invitationals because they were competing with huge schools. The team would typically do better at regionals because most of those large
schools were not in her school's region. Barbara describes one of the motivators for her as "the challenge of trying to help the kids do better and realize that they could compete with these bigger schools." She also describes a second motivator which has less to do with competition as "the challenge to see if I could get these small-town kids to actually feel good about themselves even if they don't win."

Another personal benefit Barbara has experienced is in the friendships she formed with the coaches who helped her. She said knowing that these other coaches were often from the huge schools that probably had all kinds of resources was encouraging. "Everybody was willing to help me, and everybody was very good to give me ideas and advice and stuff." She says she could ask the other coaches, "Hey, what do I need to do? How do I build a plane? What are you using?"

Barbara feels that Science Olympiad allows her an opportunity to see her students in a different light. "I think it's just different when you know them outside the classroom." She thinks it helps her to relate to them more because things are more laid back when they are at practice. Because she must get through a certain amount of material in the classroom there is not time for students to tell their stories. She describes how the students are freer to express their interests to her because Science Olympiad is a more interactive environment and the students are not having to just sit and listen. She says that sometimes students are a behavior problem in the classroom, but they are different outside. "It's more of a personable environment and I think that's good for a teacher to have that outside to not just see them in the classroom." Barbara can take that back to the classroom somewhat. "That helps me see what they like and that the handson is important."

Barbara responds, "Oh, definitely!" when asked if getting to know her students through Science Olympiad outside the classroom affects the way she teaches her classes. She says that when you get on a personal level with the students and are doing a lot of hands on with Science Olympiad "you see how much they like doing that and they express to you 'I really like doing that'." Often, they will ask her in class, "Can't we build a bridge?" She says that in class they are always begging, "Aren't we doing something today? Are we going to the lab?" Barbara says that is tough because with six or seven preps each day, she does not have the time to be setting up labs for everyone as often as the students would like. However, she tries to as much for them as possible because of the Science Olympiad feedback. "That helps me see what they like and that the hands-on is important."

Science Olympiad has also given Barbara motivation for some personal learning. She admits that she has no shop skills. "A lot of the kids taught me how to run a drill because I didn't really know how." A parent came in and taught electronics to both her and the students. She says there has been a lot of learning along with the students through the years and this has been some good personal growth for her. "It got me out of my comfort zone to learn how to do some of that stuff."

The things that make her want to keep doing Science Olympiad every year is the opportunity to witness student success. She describes success as "the look on a kid's face when they accomplish something they didn't see right off". She says it is when the student says, "This is never going to work" but it does. "You know, when their bridge holds all the amount [planned for] or when their car hits the mark or when they get a medal." Barbara talks about the excitement when her team who could barely make it to state had two girls win their category at state. "We were so excited that we could do something like that." She says she just enjoys
watching students do things they didn't think they could do and to just compete even if they only do okay in it. "It's rewarding in itself." After describing this she pauses and says, "I can't talk because I am tearing up over here."

## Perceived student benefits.

For students benefits, Barbara talks about the skills gained by students. As mentioned, she is in a farming community so many of her students have skills with things like running power tools, soldering, and electronics. She knows this is not common for all schools. "My brother is an engineer and he does robotics and he's with inner city kids and we talk about how they don't even know how to use a screwdriver." Barbara is fortunate in this and can have students teach other students these skills.

The mentoring goes beyond tool usage skills. Barbara tries to pair older students with younger students in the same category so that the older ones can teach the others. "I try to put some $9^{\text {th }}$ graders with $7^{\text {th }}$ or $8^{\text {th }}$ graders to teach them. She says they do not like it too well, but she tells them, "You've got to teach somebody what you know because you're going to be gone." She comments that it is nice that the younger ones look up to the older ones that are helping them. "They do form a camaraderie, you know. They do respect each other, and they help each other."

Other skills that Barbara sees students learning beyond tool skills are more focused for testing events instead of the builds. She says that the research related skills of organizing notes, determining what is important, and fitting it all onto a page that can be taken into the event are important. The students have learned some computer related skills such as how to do documents and graphing. She said this was very difficult for the students at first when they switched from Word and Excel to Google Documents and Google Sheets for easier sharing of notes with teams from other schools. Another aspect of the research is time management. She says that the older
students are better at this than the younger students. She thinks that maybe the older students have learned how much time it takes and they know they have only so much time. The younger ones like to sit and talk or be on their phones. "I can't get them to realize they aren't using their time wisely." Some of this could be because the younger ones don't know where to start with notes without some mentoring. "It's hard to get them to realize what they need on those notes."

Barbara sees students bringing knowledge from Science Olympiad events into the classroom. She says that students who have done Solar System or Astronomy always score better on that in class. In the classroom discussion Science Olympiad students know a lot more and can contribute to that discussion because Science Olympiad pushed them to have to learn beyond what is presented in the classroom. She gives an example of a student. "In class we got to talking about waves and he knew all kinds of stuff that I don't think he really realized he knew." She assumes that similar acquisition of knowledge in subject areas she does not teach is also happening, but she would not see that since it is outside her class.

Another experience Barbara sees as a benefit to her students is the opportunity to travel to the larger schools that host invitationals. The students get to see things in a larger school classroom or college classroom such as animals, fossils, or skeletons that she does not have. "They would see more things in a science classroom than I have." Her students seem to get excited about that by their comments of "Did you see that in there?" They also get to use equipment they would not otherwise have an opportunity to experience. She mentions an event where her chemistry students came back saying, "Hey, they had us using this piece of equipment. I had no idea what it was, but I think we figured it out." She thinks just the exposure to equipment beyond her school's simple microscopes is important for students.

Barbara does not have any specific examples of students choosing a career in sciences because of their experiences in Science Olympiad. She has had students go into biology, chemistry, and biomedical fields. She cannot say that their choices were due to Science Olympiad because the students were likely already interested in those events beforehand. However, she thinks it might be possible that their participation in those events lead the students to consider those areas for careers instead of just a passing interest.

Students who do not play sports do seem to find a home in Science Olympiad. She says, 'I've had kids and parents tell me that if I wasn't doing this, their kid just doesn't have an interest at school." Having this niche gives the student something to be proud about. Barbara describes how pre-Covid she would make sure there was a school assembly for the Science Olympiad teams to show the school what they were doing. The builds are the only part that really get shown off because it is difficult to show a testing event. The elementary students would be invited to attend the assembly to see what the Science Olympiad teams were doing. She would have the students test a bridge and show off their robotic cars. She says that sometimes the students are reluctant and say things like, "Oh, you know, it'll probably break." She responds with, "So what? You've got something that's really cool here that most kids don't even know what it is." She encourages them to show it off and tells them that if it does not work right, they can show it off at another assembly before the team goes to regionals. Additionally, students are sometimes reluctant to take their build to competition because they feel it is not like something built by an expert. She tells them, "We go with what we got, and I know you built it." She will acknowledge with them that it may not be the best-looking device but encourages them with "it's going to be something you built, and I hope that you're proud of it because you did it and I didn't and your parent didn't." She is very insistent of this because when the student does
win or place with either their build or in a test, she wants them to be able to talk about that. She wants them to have the benefit of "that pride of doing something that maybe they didn't realize they had in them." Beyond the assemblies, students get additional publicity in the school newspaper.

## Workplace and community support.

Barbara has already talked about how supportive other Science Olympiad coaches have been. Her school and community have also been supportive. Early on her superintendent said he would help her out with expenses. She still must do some fundraisers. She mostly does bake sales because she has a lot of parents that can bake. There are some good community supporters who will buy a plate of cookies and give the club fifty dollars. She says that they were appreciative the school was trying to offer the students something that was not sports. "And I have a lumber yard that if I need some wood or some scrap something, he digs it out for me and donates what he can." There used to be a time when she had a team membership fee, but she did not want that to prohibit a student from joining and she has enough support that it is not necessary now.

Because, as Barbara stated earlier, she does not have shop skills, she has received help in that area from several school custodians who would volunteer to supervise students using the shop equipment because the students could not be in there by themselves, and Barbara needed to be helping students elsewhere. Some of the teachers have also come in to help the students with their notes. The other teachers have also been supportive in allowing the students to leave class for a few minutes at the end of their hour to work on Science Olympiad.

Pre-Covid Barbara had a lot of parental help. Since Covid she has asked, "Send me this, this, this, or send me money." She says she gets mostly money but money does not solve
everything. Mostly she needs people to volunteer time. So, she talks a great deal about the help she used to get and would like to have again.

When the very first team went to their first tournament, they took their own lunch boxes. They caught glimpses into the other schools' homerooms. "We saw these massive amounts of food that parents had brought for their kids." After that she asked parents to donate food and drinks and then a fellow teacher and her husband took over the food and organized the parents to send food. Barbara says this got the parents more involved and so some of them started coming to the tournaments. That turned into a big following that would ride the bus with the team. They would volunteer to help with events by test grading or assisting inside the event. Some parents would stay in the homeroom. "They would keep the kids entertained because it does get kind of boring when you're not in an event for an hour or two." She says that the students liked that and would quickly learn who the fun parents were and request them for the next tournament.

Some parents did have skills to help mentor events. She said she had several dads who were skilled with electronics or electricity. She found that some parents were really good with organization and could just sit and help the students organize notes even though they did not have any particular expertise on that topic. She says that some parents were just interested in the topics themselves. "They thought it was kind of neat to learn about some different things."

Barbara did find that too much parent support could be a drawback. Sometimes students would rely too much on the parent and other times the student would tell her that they wanted to do more than the parent was letting them do. "So, I kind of backed off having too many parents come in unless I really needed some help because I didn't understand part of it." She says that the parents are competitive like she is, and they want their student to have the best device. "They don't realize that they can't do it for them."

## Perceived Challenges of Science Olympiad Involvement <br> Personal and coaching challenges.

The major drawback for Barbara is time. The students want to practice for their events and she needs to get materials for them, but she also needs to be grading and preparing her lessons for the next day. She mentions that the Crime Buster's (a short description of Division C events are given in Appendix U) event needs to have a lab set up for the students to practice yet she has previously stated that she does not do labs for class as often as she or the students would like because of the time it takes to prepare a lab. She says that it is a challenge to balance her time between classroom and Science Olympiad. She no longer has a science club for people who do not want to compete. When she wanted to add the competition, she just thought it would be something fun. "I didn't know how time-consuming that would end up being."

For about a year Barbara decided to not have a high school team because running two teams was hard on her. "I tried to stop it because I just could not keep up with 46 events." Her high school students convinced her to let them have a team. She agreed, "Okay, I'll let you have a C team, but you're on your own time." The middle school students seem to require more coaching because of their inexperience. They do not know what they need to do or how to manage their own time well. "I can't get them to understand that they've got to come to practice now and not a week before we are ready to go."

Barbara finds some drawbacks in the fact that she lacks some skills. She has already mentioned not having shop skills and has been fortunate in having people around her to help there. She also comments that she is lacking in computer skills. This has caused issues most recently with getting things submitted for virtual competitions. "We would have trouble with the video wouldn't send or I wasn't doing it right." She also does not feel like she could ever host
an invitational. Even if she could manage to get the space and the volunteers, she says, "I don't know the computer skills to put the scores together."

When talking about support, Barbara indicates that she has a good amount of support, but there are some issues. She is the only coach and does not have an assistant coach. Part of this is due to school size and she is the only science teacher, so no chance of getting a close colleague there to help. The next logical step would be to ask the math teacher to help, but the school has had trouble in finding and keeping a math teacher. She mentioned that she does get help from parents, but then she had to get cautious about parents helping too much. Also, Barbara has mentioned how other Science Olympiad coaches have helped her. She is losing one of those close mentors who is retiring and moving. He had run a winning ream for years, was regional director, and hosted one of the biggest invitationals in the state pre-Covid. She says that he told her he had lost a lot of his help, too. She is concerned that no one will come in and pick up what he was doing. "He was a really good mentor for me. I hate that he is leaving."

Being a small school means a small student population from which to recruit a team. She says that she does not have the pick of only her top students. When asked about how she recruits she laughs and says she just puts out a sign-up sheet. "I don't' beg. I don't plead." She admits that if there is a student who she thinks would be good at Science Olympiad, she might say, "Hey, why don't you try?" She says that she has found in the past that if she has to beg a student, then it is not something they really wanted to do and they end up quitting. She rarely gets over 15 students and so she goes with whoever signs up and she says that some of them do not take tests very well. "There were only a few years in there where I got to pick and choose, but basically it's just whoever signs up." This year she covered all 23 events with 12 students and if there were not volunteers for some events, she just chose some students and said, "You are
entering this no matter what" so that the team could have participation points if nothing else. She says that sometimes she has a hard time getting them to prepare for the testing events. "Nobody wants to do the notes and take the tests. They just want to build."

Barbara talked about having better relationships with her Science Olympiad students as a personal benefit, but she also discusses how it can be a drawback in the classroom. She says that sometimes in class her Science Olympiad students might get a little carried away with joking or talking and she must reel them in. "Okay, this isn't Science Olympiad, you know, this is my classroom." She says that it does not go unnoticed that there is a difference by the non-Science Olympiad students. Sometimes the other students will throw it back on her that they think there is some preferential treatment. "Well, he's a Science Olympiad student. They're going to get to do something we don't."

## Perceived student challenges.

Time management and lack of commitment are the two major drawbacks that Barbara sees for students. She says that if there is a conflict with a sport activity, the sport will always win over Science Olympiad. However, it is not always school activities that cause problems. "Sometimes it was the parents that didn't understand that Science Olympiad was just like everything else." She says she always sends a signature sheet with the parents so they will know the dates of the tournaments, but inevitably they plan other things anyway. She does not think they would do that if it were a sporting event. She feels that after a student has spent all that time practicing, they deserve for the parents to make sure they can attend the competitions.

Sometimes, it is the students who are avoiding coming to practice. They will tell their parents that is what they are doing, but they will go do something else. Barbara says that she holds practices at least three days a week for an hour to an hour and a half. Since Covid, she has had a harder time. "The group I have now is not as committed, so to getting them to stay for an
hour was a stretch." She says she lost all her older students due to lack of motivation. They did not like the virtual tournaments. They told her, "I'm not signing up if we're doing virtual. You need to promise me we're going to go somewhere." Barbara says that almost all the in-person invitationals are gone, so she does not have anywhere to go in person before regionals.

Some of the other drawbacks have already been discussed under other areas. Parent support is a good thing until it becomes too much. Then it is a drawback for the student. Barbara says students have told her, "I don't really want them in here. I want to do it." Time management is a skill that is a benefit once learned, but lack of it is a drawback until it is overcome. Especially with the beginning middle school students Barbara says, "I can't get them to realize they're using their time not wisely."

## Advice to Those Coaching Science Olympiad

Barbara's advice to a coach wanting to start a team is to get help and organize. "Get help from another coach that you think might help you get started and then organize, organize, organize because you've got to be organized." She says you do need to specifically ask coaches for help, though. With two teams of her own to run, she does not feel she has time go out and actively recruit other schools to start Science Olympiad teams. However, she has always been willing to help a new coach get started if they "Well, I would but nobody really came to me that interested. I would have, but they would say 'Oh, that sounds like fun. Oh, I'd like to do that.' But then, you know, they never really asked anything specific."

She also recommends going through all the rules before starting and make the student do it, too. She says for both builds and tests to not let them start anything until they understand the rules. "I made them sit down with their partner and highlight everything they were going to have to know or do because otherwise they just start and they don't really know what they're doing."

As a starting coach, Barbara says she had a big expense for all the electronics and wheels and materials that she did not have. She spent a lot of her own money before she started doing fundraisers and the superintendent said he would help. So, that is something to be aware of and a new coach needs to plan for that.

## Appendix I: Beth's Science Olympiad Experiences

## Introduction

Beth is a volunteer coach who coached for two years at a Middle School for grades 6-8 and currently coaches at a high school in state A. The Middle School's locale is characterized as Suburb, large. School data for the year 2019-2020 gave 623 total students and 38.10 teachers with a 16.35 student to teacher ratio. Race/ethnicity numbers indicate 488 White, non-Hispanic; 50 Hispanic; 42 two or more races; 24 Black, non-Hispanic; 18 Asian; and 1 Native Hawaiian, Pacific Islander.

## History of Involvement in Science Olympiad

Beth is an aerospace engineer who first became involved with Science Olympiad while working for Boeing in Seattle. "So, I was in a group called Society of Women Engineers and we did a lot of volunteer things." She says that she especially worked with Girls Scouts doing science camps and overnights at the Museum of Flight where they would do fun things like set off rockets. They also had a program where they connected teachers with engineers. "It was really good and I was paired with a fourth-grade teacher and they had elementary Science Olympiad (Division A) in his school and so we did some of that with him." Her involvement progressed from helping there to being asked to be an event supervisor for regional and state tournaments. "So, it was really fun and that's before I had kids."

Beth moved to State A and when her daughters were in middle school, she and four other moms decided to start a science club. "That's when a lot of funding got cut at our school and everywhere for schools." Because of that, she and the other moms decided they needed to do science with their kids. "And from the club, we formed Science Olympiad teams and robotics teams." That was in 2011 and Beth coached that Science Olympiad team for two years until her daughters went into high school. Then Beth started the high school team and has been coaching
ever since. For a long time, Beth coached both the middle school and the high school teams, but now there is a teacher in the middle school who is coaching that team. "We quit doing the science club at the middle school so much and just focused on Olympiad at middle and high school and the robotics teams are still run by the parents of the kids in it."

## Perceived Benefits of Science Olympiad Involvement Personal benefits.

Beth is not a teacher at her school, but for the past two years, she has received a stipend for her efforts. "My principal really fought for that, so it was nice of her. It had been a thing in the past, but that was when a teacher had done it." "It pretty much goes back into Science Olympiad, but it doesn't feel bad anymore. I'm not spending just our own family money. It's good." She does have a Science Olympiad budget which is discussed in the support section.

Beth does not give specific personal benefits to coaching Science Olympiad. "I just think it's really important." She laughs and says that her whole goal is to ensure that students get an opportunity to do academic and science related activities as much as the sports and traditional school activities. "Especially in public schools, I think that can get unbalanced. So, I think it was unbalanced for a long time and hopefully it's getting better." "I love the part that they get their medals."

When asked about coaching a successful team, Beth says, "I don't believe we've actually ever won regional, but we've gotten second place at regional which was good." She says that they generally fall somewhere in the $4^{\text {th }}$ to $6^{\text {th }}$ placing in the team competition. "It gets us to state [level competition] and they've learned something." She thinks it is success when a student comes in and says, "I got a bronze in Chemistry." She knows other coaches want to win and move on, but that should be the team's decision. She tells them, "You know, if we actually made it to nationals that would be a miracle, but, you know, if you guys really want to fight for it,
that's fine with me." She says that she knows how much time the students have available and she does not think it is realistic. Her high school team has gone to state year except the first year. She says, "the middle school almost always goes to state as well which is a much bigger deal because there's so many more teams competing."

## Perceived student benefits.

Beth sees Science Olympiad as an opportunity for kids who want to do science but can't fit an advanced science class into their schedules. "I mean, especially if you're a musically talented kid or a theater talented kid, or you know things like that, or a lot of our kids are in debate, and in forensics and they have a lot going on." She thinks Science Olympiad provides a place for them to hear the ideas and concepts being discussed around water and ecology. "I think that's really important for them to hear as well."

Beth did not have the benefits of Science Olympiad while she was a student. She talks about her experiences pursuing a degree in aeronautics. "I came from a very small school in [State A]. I was top of my class, but when I got to the University to study aeronautics, I knew nothing about airplanes. My classmates all knew everything," she says laughing. "I struggled a lot with that just knowing what they were talking about and understanding concepts." She thinks that is what Science Olympiad does best. It introduces so many different concepts to students that they may not get elsewhere. "Kids that don't take Physics may get exposed to those concepts in builds. Kids that don't take advanced Biology or Chemistry will learn a lot in those events. Just hearing the ideas and the concepts being discussed is important."
"They can choose out of so many different events that cover so many different areas of science; but then once they choose that event, then they tend deeper into that than they do in the classroom." Beth adds that if they really want to do well in a Science Olympiad event they must go deeper. "You might talk about birds in Biology, but in Ornithology they're learning all the
differences between the types of birds and even the calls, which you aren't going to get that in a biology class." (Short descriptions of Division B events are in Appendix T and Division C events are in Appendix U.)
"Well, it's just so much more in-depth," says Beth. "If they started doing Anatomy \& Physiology events in $6^{\text {th }}$ grade and go all the way up, when they hit AP Biology or take A\&P in High school, they may not know all the answers, but they have the vocabulary."
"At the beginning of the year, I spend the first four meetings going over the events and what each one requires." Beth talks about how she informs the students of their options. "I give them a form that lists all of the events (Appendix D gives an event list for Division B) and they mark the ones they are interested in. Then we spend the month of October negotiating who is actually doing what events."

Beth says she asks her students, "How many of you think you might be an engineer, a doctor... some kind of science?" She says quite a few of them raise their hands. In that conversation they will see that Science Olympiad is more important to them than some other activities such as sports. "But then, of course, the group that I pull from really don't plan to be professional sports, also." In looking at past students who have continued to pursue science, she says, "From my daughter's class that just graduated from college, I know six female engineers that were associated with Science Olympiad. And then I know of other of their male friends that have gone on to be in medical and engineering," Beth adds. "They have really good positions and are doing well even in these bizarre times. They either have jobs or places to go in grad school."

When asked about high school recruitment she says, "I give them snacks!" and laughs. "They have a time that's a seminar time on Fridays and so that's when I go in and touch base
with my kids and I bring snacks. I think it's a lot of word-of-mouth too because they talk it up." She describes how the students already involved in Science Olympiad will brainstorm about who they know would be good in certain events and then they try to get those students into Science Olympiad. "They're really good at recruiting themselves." She hears them say things like, "Oh, I know somebody who might be really good at this event!" Then she sees them try to pull that person into a meeting. At the beginning of the school year there is an assembly in the auditorium and anyone who is interested in learning about Science Olympiad can come. She says that typically she just gets her returning team members and the eighth graders coming up from the middle school team. After that they go out and say to their friends, "You need to come to this!"

Beth sees that her group is somewhat homogenous. "Definitely, they're nerds and they're lovely. I mean, you know, of course, there's a little bit of stigma with anything that says science, right?" So, she does see that it attracts a certain "crew" as she refers to them. However, Beth promotes taking all comers as a benefit to the students. She describes another team she knows that holds tryouts and only has the 15 who will compete all year. She says that a student gets onto that team as a middle school student and then typically continues throughout their school years. This makes for a very focused and competitive team, but that is not the type of team Beth wants.
"Actually," says Beth, "we try to catch them in Middle School because, especially with sixth grade, they can't do any of the team sports and things like that." Beth explains that her state has a ruling banning $6^{\text {th }}$ graders from competing on school sports teams, but Science Olympiad is not impacted by that ruling. So, she says that the middle school team is heavy with $6^{\text {th }}$ graders and then they lose students as they can join sports in $7^{\text {th }}$ and $8^{\text {th }}$ grades. They also compete with music and theater. Though she is now coaching at the high school, she says, "I
still spend a lot of time with the middle school team because that helps me know what's going to happen for the high school." She acknowledges that the middle school team is a major component of her future high school team. "I have an awesome class coming up for senior year this coming year. I also have really awesome incoming freshmen class this year."

Beth explains her process:

Oh, the other thing I do is I do a little presentation at the beginning like an overview over what each event is and then I spend about four different meetings - I split the events into to four groups and we go more in depth on what each group, you know, has and what's required like if you have a one-page note sheet or if you can take a binder or, you know. One day is completely devoted to the builds and these are the things you have to have and so once the kids actually understand what each event is sometimes that helps with- I mean, kids definitely drop out. That "Oh, you know protein modeling sounds really cool" and then they find out what you have to do and they're like "Oh maybe not."

Invitationals are a benefit to the students. "I mean we can only have one team participate in regional and state, but if we go to invitationals, we can take as many teams as we can fund." Beth describes how she can run an invitational and a regional at the same time. "So, the kids all go into the events the same way, but then when we score them, we just pull the invitational teams out and score them separately."

Because Beth takes all those who want to participate, she has had students join the team as juniors or seniors. She says that they may only compete in one event at invitationals with no plans to ever be on the competitive regional team. She has a story to tell about this. "Oh, my goodness," exclaims Beth. "At regional once we threw a guy from the invitational team who hadn't practiced with us at all into an event." This student was on one of the Science Olympiad
teams at the school but was not trying to be on the team qualifying for the State competition. "Somebody got sick that day and the partner left doing the event didn't want to go in alone. So, we grabbed this guy, and they went in and actually medaled. It was great!"
"Me saying I'm the coach is very loose," says Beth laughing. "I just try to take the burden off of them of all the paperwork and making sure everybody's at the right place at the right time and have the equipment they need." She describes herself as more of an administrator. She says it is the kids that decide how the team's going to run each year. Especially the juniors and seniors are the ones saying "OK, so we don't have a lot of time now, but we need to work on this, and this is how we are going to do this." She says that they are pretty good at selfregulating. "I know other High Schools where the kids actually drive it, and they have some teacher that is just like the figurehead and then the kids are the ones who manage their whole team and the whole experience." She says where she has seen this happen is when a school had a really solid coach who leaves, and the students decide to just carry on and keep it going.

Beth says, "I have kids join as seniors, you know." She says they think, "Oh well, that is cool and those are a cool bunch of kids." She continues, "They may only compete in one or two things and may only go to invitational meets; but, you know, they're happy."

Beth says, "I even have supporters." These are students who would like to be on the team but cannot commit to the time. "They just come to seminar and have snacks and talk to the other kids," she says laughing. "But, you know, they generally are pretty interested, and they help me when I have regionals. They'll be people that show the kids to where the rooms are. They sit in the front, you know, and do registration for me." She mentions that these are sometimes her juniors or seniors that were previously on the team but had to leave due to time
conflicts. "They don't - a lot of them just don't have time to give to an event, but I figure, you know, they're in the room. They hear the science stuff. It's all good."

Beth says that she has seen her students bloom over the years. "My little sixth graders come in squirrely as all get out and can't focus on anything and, oh my goodness!" Then when they are in high school, she sees them participating in Science Olympiad as well as other outside things. They are presenting themselves well and working together as a team. She believes it will help them do well in their future.

Students learn to be flexible in working with others. "If you're paired with somebody at an invitational, you may be paired with somebody else at regional." She explains how that may be more common for the testing events than the builds. "These two people built it, and they have more ownership in it.: However, things happen and one partner may not be able to attend an event. That is when she hears the remaining partner asking, "Oh, okay, can so and so work with me on this event?" She says then she lets them figure it out. "These kids are typically the kids in the college-bound classes." She says that they probably have all the AP classes together as well as interacting in Science Olympiad. "So, they know each other's strengths."

I ask for evidence that the students enjoy competing. Beth laughs. "They keep coming back! They talk about it." Beth gives her graduating seniors cards and a small gift from Science Olympiad. "This year I gave them these little stickers of the brain and it says, 'Use it well'." Over the years she says that she has received many thank you cards. She says that some of the cards have messages like "I appreciate all the time you spent" or "I really enjoyed Science Olympiad".

Beth talks about what the medals mean to the kids. "I had a couple seniors that graduated tell me, "This is the only place I've ever gotten an award." She liked the way Science Olympiad
gives out individual medals for rankings in the events in addition to the overall team rankings. "So, any kid who gets any of those medals is acknowledged at one of the Board of Education meetings."
"The amount of medals and the place we win with the trophy don't really matter as much to me," says Beth. She wants to see the kids happy with what they have done and explains that she feels successful when a kid gets a sixth-place medal at a Regional event and she hears them say "Oh my gosh! I got a medal!" and be truly excited about it. "That to me is as much success as like getting all first." She shares that she had a couple of seniors that when they graduated, they told her, "This is the only place I've ever gotten an award". The awards structure is one of the things she really likes about the Science Olympiad competition. "The way that Science Olympiad does it, you can get medals for all the different events that you do." She explains that each student gets medals for each event they place in addition to the team having an overall placement.

On the issue of state test scores Beth says she can only respond to what the school district publishes. There are two public high schools in her area and testing scores are always a competition between the two. Her school has always had higher math and science scores than the other high school which has just recently started a Science Olympiad team. However, she is not sure that science Olympiad can be credited with all the differences. She thinks it also has to do with family and environment. The families at her high school are interested in science and STEM and push their kids in those areas. She says that is why they have had Science Olympiad at her school for the past 12 years. So, Science Olympiad may be helping boost the scores or the scores may be high due to the community emphasis on STEM and the Science Olympiad team is a byproduct of that interest.

Beth reiterates the importance of the team having a space of their own in the school. "The fact that now we have a place where we can store our stuff is just amazing because we can store our old files and, especially with events like Anatomy and Physiology, it rotates." This means that the event is included in the competition for a year or two and then is not done for a year or two. She mentions that Astronomy in the high school and its middle school counterpart Reach for Stars as well as the middle school event Solar System also rotate. "The kids can go back and pull out the old note sheets, take those, and change them around. We've tried to have a database of things like that, but the paper files seem to do the best." As mentioned previously, the school allows the team to meet during the seminar time on Friday. This helps reduce some of the out of school time pressure on the students, but Beth explains it is not a large amount of time. "They squeeze it between like second and third hour on Friday and I don't get it every Friday because that's what they use to do like assemblies." She says she will also lose her juniors sometimes for ACT prep and the seniors will get pulled out graduation related things. "I usually don't have the whole team at any given seminar, but it's enough that we can coordinate and then they can go out and talk to their event buddies."

## Workplace and community support.

"The importance of having the administration buy-in is key," says Beth. "We started at a time when there was no funding for anything like this. They've helped us buy equipment and fund the kids traveling to different invitationals and things."

Beth says that the school always pays the entry fees and then she has a budget as well. "They give me a budget and so I can use that for any kind of materials we need or, oh my gosh, recently it's all gone to transportation just to try to get us to other invitationals." She is hoping one of the other schools in her area will start to do another invitational so her teams can get more practice with less travel. "Busses are very expensive." To help with the time issue at the high
school level Beth says, "The really lucky thing is that our administration will let us practice during school." That is the previously mentioned seminar time on Friday. "Our administration has just gotten more and more helpful." She says they have been given a room they can use." I've put shelves in there and the kids can always meet in there with me."
"I have awesome parents," says Beth. She talks about how the parents help her to herd the students at events and some of the them coach events or help run events when her school hosts a tournament. "We've actually run regional at our school for the last six years and we just had a really tough time finding event supervisors." This is what she says she asks for the most help from the parents. Event supervisors often must write the test for the evet. She describes that in running an invitational each team that is attending is asked to run an event. She says that in recent years they have dropped off in number of teams at the high school level. So, for example if they only have nine teams attending an invitational and each team sponsors one event, that leaves 14 events for the host school to find supervisors to cover. Then add the middle school also needing some events covered and you need a lot of people. Beth says that Sandra has been amazing at helping her find people. "A lot of time her people that are going to run an event at state want to try it out before they get there." In addition, some of the parents may assist the event supervisor in proctoring the test for the event, some of them help score, and others provide food. "We usually have a couple parents who just sit in our homeroom and make sure that kids get to the right place at the right time, and they know what they're supposed to take."

Beth describes some of the after ways in which parents help. "Some of them are very helpful in a certain topic area and so they're like the teachers. They'll help with a certain event group. Things like that. They'll write tests for me. They'll proctor tests for me." When a school hosts a tournament, the school must provide tests for the events that have paper and pencil
tests. These test for each event is usually written by the person running that particular event. The school must also have volunteers to proctor the tests in each of those events. Building events also require volunteers to monitor and time those activities. If a school is hosting both middle school and high school, this can be as many as 46 events requiring at least one volunteer per event. She also acknowledges that she also benefits from the nearby aerospace community. "We have a lot of engineers." She laughs, "I have friends that do aerospace and so they always help with the aircraft and the rocket type events." She has other parents that help with what she refers to as the trajectory type events and car type events. "So, when we have a specific event that year, I usually know who to call."

When asked to describe how she recruits parental help, she says, "At the beginning of the year, I let them know that their kid is signed up to do Science Olympiad because some of them have no clue." She uses a program called Sign-up Genius to make it easy for the parents to see what is needed and volunteer where they can. She asks the middle school parents to bring snacks for the weekly after school meetings, but she supplies the snacks for the high school team herself. When it comes to certain events that rotate, she will call on past parents who coached those events to see if they would be willing to come back and help. "It's nice because usually we have siblings, you know. Like if the older kids do it, then the younger kids just follow along. So, I can keep my parents for longer."

Beth says she benefits from being near a city that has a university and some technical companies because that gives her a lot of parents with STEM backgrounds as a knowledge pool. "A lot of my help comes from parents, originally, you know, of kids on the team and then they just stick with me. So, it's really nice." She is referring to the parents who are still helping even after their children have graduated. However, this is changing. She says that when she first
started coaching, she had a lot of supporting moms. "Especially moms that had taken time off to raise kids instead of doing their technical type thing, but as time has gone on, it just seems like more and more of them have gone back to the workforce earlier." Beth is referring to women who are engineers or have education in other STEM or technical fields and whose input and help was very valuable for SO. Both the increasing demand for employees in those fields as well as rising costs mean more women are returning to work while children are still young rather than seeing them though elementary or middle school before returning to the work force. She says she has a lot of help, but she definitely does not have a coach for every event. "And I can't imagine finding that."

In this last comment, Beth is referring to the private Catholic middle school where Laura in Appendix K coaches. She knows Laura as a fellow coach and talks of the type of support Laura has from parents. "That's their church community on top of being their school community." She thinks that makes them a very close-knit group. "Like I have a huge loyalty to my school district because my kids all went there, but that's not tied up with my work and my social life. Theirs is all one together." She says that they have a very strong loyalty from their alumni who will donate or come back to help coach and she sees a little bit of that at her school. Most of her graduates have gone elsewhere to pursue college or careers, but some of them do come back on weekends to help on workdays or come to help at the yearly regional tournament.
"I do have a lot of really great teachers," says Beth. "They'll write tests for me. They'll help me on regional day." She says that the kids will study old tests. "My background is, of course, engineering so I try and help them with the builds, but I'm not that great with like protein modeling and things like that." If they have specific questions in chemistry and biology, she says the teachers with expertise in those areas do help. She gets help from both science and non-
science teachers at her school. She laughs as she tells a story about the protein modeling situation. "I have a wonderful art teacher who helps judge protein modeling for the last few years because it's got sculpture and she also has a math background." The teacher in charge of their gifted program has a biology background and helps students with those questions. Beth is appreciative of all the teachers at her school. "They're great. They would like to help more, but it just comes down to how much time they can commit." In addition, she reports that they have given her permission to use anything in their classrooms. She is also grateful for the cooperation during the tournaments. "The fact that they open up the high school to us and we use every room in that high school including individual teacher's rooms is really nice."

When asked about getting emotional support from her administration, Beth says, "Like my principal and our activities principal who is the activities coordinator are both so supportive of us." She sees that school support in general is important. "So, I think the emotional part is not just important for the coaches but it's important for the kids too, you know, to be supported and appreciated by their peers." She describes how the whole school supports them. "It's really great when they actually cheer us on like with sport teams. Oh my gosh! It's amazing." Her School Board and Superintendent are also supportive. Beth tells how the Superintendent comes every year to the regional competition to check it out and they make sure that there are tweets and information on the school website about how the team did. "Because we have regional in our school, that's always a big deal for the school."

For publicity she says they have an email blast that goes out every day to tell everyone what is going on at the school. It goes to the teachers who pass it on to the students and at also goes to the parents or anyone that has access to Power School. "They put us in the newsletter just like the results from the sports teams. Also, at the end of the year, there's an activities award
ceremony and Science Olympiad is recognized there. The kids can [earn a varsity] letter in Science Olympiad." She laughs as she tells a story about the school getting the letter insignia for Scholar's Bowl mixed up with the one for Science Olympiad, "There is an actual Science Olympiad one."

When asked about the importance of interacting with coaches from other schools, Beth says, "It's really important. It helps a lot to just have people to talk to, but more than anything coordinating for regional is just I have to talk to the rest of the (especially the high school) coaches." She continues, "We have another middle school that coordinates the middle school part of the regional but then I end up talking to them a lot too because they're all coming to our high school." She says that there is a web page used by her state and a neighboring state that the coaches use to coordinate what is going on. She does not indicate that there is much social interaction or exchange of ideas going on there. "We have one meeting in October where we get together and Sandra (the State A Director) talks about the new things for the year and what the plans are and things like that. But it's hard to get the high school coaches together." She says that when she was coaching at the high school her communication with other coaches was only when putting together the invitational tournament and just communicating with the coaches about getting them to invitational tournament. Otherwise, there was not much communication about anything else. "I feel like now there is more talking between coaches across schools and I think that's great as long as they think it's great too." She laughs.

Beth says that communication in the school is also important. "Especially since we have multiple coaches doing the different events within the school, it's great just to know how the practices are going in that and then also just communicating with them about how the students are doing." When she is making up the final team for state, she says, "Communicating with the
other coaches about what students really stand out in the events is pretty much a necessity in order to put your team together. And then communication about resources that are needed and then also preparing for tournaments."

## Perceived Challenges of Science Olympiad Involvement <br> Personal and coaching challenges.

Beth discusses the negative side to the earlier benefit of Science Olympiad not falling under the rules for team competition helping in recruiting $6^{\text {th }}$ graders. "If we were a recognized team event, then our school would pay for our bussing. Bussing costs have just gone up tremendously in the past few years." She likes to take her team to participate in several invitational tournaments for practice before regionals and state. To do so, she must travel to another large city in her state or to a large city in a neighboring state. From her location, the two are about equidistant. "It would cost us maybe three to five hundred dollars, but recently, I think that last trip out of state cost us $\$ 1200$ in bussing. So, you know, it's gotten to where we almost just can't go unless the school helps us." Travel is not the only expense. There are participation fees and equipment costs involved as well.

In addition to travel there are other costs for a team to compete. "So, it's probably almost $\$ 300$ by the time we pay all the fees, you know, to enter State," Beth explains. "Then, if we go to invitationals, some invitationals have fees associated with that."

Beth mentioned becoming involved in Seattle with a Division A (Elementary School) team, but as far as she knows there are not any Division A teams in State A. She says it is hard enough to keep Division B and C going without starting a Division A team. She says that the high school is especially hard because it is hard to get coaches. At her school she does not have problem with student interest. "I end up with like 40-50 kids interested in doing Science Olympiad every year, but I know other schools struggle even to get the kids." Beth estimates that
her school has 900 students $9-12$ so smaller schools would have to have a larger percent of students interested just to find a full team.

At her school she has remained the coach for so long because the science teachers are busy. "Most of them coach other things either Scholar's Bowl or some sport or something like that." She says that she hasn't found anyone who has been willing to say "Yes, I want this to be my thing." So, she says it has always stayed her thing instead.

Even with three teams at the start, Beth states that she often does not have a full team to take to state due to conflicts. "And quite frankly a regional team doesn't necessarily look anything like our state team because just almost every year we have a music contest the same weekend as state which takes out probably 60 to 70 percent of my kids." This is evidently a recurring point of frustration for her. If the competitions are close enough together, she explains that they will attempt to bus the students between the two. "So, we try to put our best team together for regional to make it so that we are able to go to state and then whatever happens at state happens. I usually don't end up with a full team."

Beth has some experience with a small team. She says her high school team has gone to state, every year except the first year when she started it because she only had 5 kids competing that year. She explains the problem with not having a full team and the scoring system works when team does not cover an event:

Actually, you get penalized when you don't compete. You're doing the scoring at the end and it's the total number of teams that competed plus one for the people who didn't and like low score wins. Like if you have all first places, you would be the hands-down winner. But, if there are 19 teams and then you - actually, let's see - you'd get a 20 for not competing and you'd get a 21 for any kind of
violations or disqualifications. So that would count against you if you've got like a sixth place, you know, it would make it more like an eighth place. I mean, for small teams, I feel bad for them.

So, she sees that small schools are at a disadvantage from the start because "they don't have the pool to draw from on amount of kids." Since they may not have 15 members interested in joining the team, the team may be limited to only competing in 4 or 5 events. "And that's great and hopefully those kids do well, and they get their medal and but a team that doesn't compete in all the events is most probably not going to go on to state."
"That's another problem we have. We don't have very many invitationals in our area. We have to either travel to (large city in state C) or to (large city in state B) for our high school team." Since middle school teams are more numerous than high school teams in her area, there are some middle school invitationals closer to her. "They have roughly 19 teams in [the region]. We've struggled in high school. We've been around 10-12 teams at the most. She is hoping that the other high school in her city will also host an invitational so that they can have another close one to attend.

Invitationals play an important role in helping coaches structure their teams. Having mentioned multiple teams previously, Beth elaborates on how she organizes her teams. She uses invitationals to find out how she will place people on the teams. "Our High School teams we just call them red, white, and blue and especially at invitationals, we try to really spread it out so that each kid gets to participate in whatever events he or she wants to, you know." This allows the students more opportunities. "That way they can try everything. But I do recommend that they don't choose more than three." It also gives her a good idea of who is going to score the
best in the different events. "So then, when we get ready to go to regional, I try to put a team together that will do well. It comes down to builds."

For the build events she holds run-offs. She can do this at a school practice, but she points out that this is one of the reasons why invitationals are so important. In events like Boom-a-lever, Bridges, or Towers she has quite a few students wanting to participate. She can take as many students who want to do a build to the invitationals and the pair with the consistently best design leading up to regional will be the pair on the regional team. She explains that the students who are on the builds end up having to take the tests as well to cover all the events. "I love our team because even if they're not on the scoring team, they still all work together." She describes that she might have three different teams doing protein modeling for example and they work together. "Then we'll have a time where we test our builds and see which one's doing the best and then they all go for helping with that one."

Beth explains that the team that qualifies at regionals may not have the same members as state. "Almost every year we have a music contest the same weekend as state which takes out probably 60-70 percent of my kids." She says that at times the music competition has been close enough to the state location that she can drive the students back and forth between music performance and events. However, she says that if it is an entire band trip or choir, she can lose more of her students. "We try to put our best team together for regional to make it so that we are able to go to state and then whatever happens at state happens." She says that she usually does not end up with a full team of 15 at state.

Beth runs a regional at her school. Simultaneously she runs an invitational so that schools can bring all their participants to her site.

The coaches structure their teams around the needs for competition. "Because even if we take three teams, for the majority of the events that would only be six total people because you can usually only have two on an event," Beth explains the maximum number of students that can enter a single event. "Now some events like Code Busters, Protein Modeling, Experimental Design, will let you have three people on an event. So then with three teams, I could have nine." As stated earlier, she tries to let as many kids compete in as many things as they want at the beginning, but sometimes there are too many wanting to do the same event. "Then we do negotiations because sometimes there's an event that's got nobody and so I say "okay, you can have Astronomy if you also do Water Quality" you know something like that."

She usually has at least 2 teams of 15 in middle school and 3 teams in high school. She describes her interest poll spreadsheet. At the beginning of the year, she has the students fill out an interest poll and then she places all the information on a spreadsheet so that she can try to match students with interests where possible. She also uses it to know who can be pulled to fillin when she is short for an event at a tournament.

Beth says she has not experienced burnout, but she has seen it in some of the coaches who are teachers. "They're stretched really thin." She says she has seen some just decide, "I can't do it anymore." Other coaches have become sidetracked into something else. She gives the example of one coach at a small school who got involved in make a green school. She says they dropped Science Olympiad for a few years because they were busy fundraising and doing things like installing solar panels. The team did come back afterward, but Beth observed that they seemed to have experienced many of the new team problems again.

## Perceived student challenges to participation.

When asked if she sees student burnout, she says that she does see burnout with her some of her students. "I do and, you know, especially with the seniors when it comes to state." She
says that state is in April and there are so many conflicts for the seniors. "They've got prom and they've got graduation and they've got applications and college visits, and yeah. And music contests and, I mean, just - it's just a lot." So, with her seniors is where she sees the greatest burnout.

As students get older their schedules get busier. Beth points out that if they have been doing similar events since $6^{\text {th }}$ grade, they can have some really good note pages and not have to spend a lot of study time their senior year but still compete well. She uses her son as an example. He was in Disease Detectives from the time he was in sixth grade all the way through his senior year. In this event teams use investigative skills to answer questions about disease transmission in a population. This team competed in both Division B and Division C, so they would have experienced the additional challenge of doing statistical analysis which is added for the Division C competition (Science Olympiad wiki Disease Detectives). "He and his partner had really good note pages and they didn't do a whole super lot by the time they got to high school to study for it."

Beth laughs. "OK, this is really interesting. As we go along, usually the freshman are super interest in all the builds and they're the ones gung-ho about it. And then by the time they get to be juniors and seniors they are like, "Uh-uh, I'm just doing test events. So, they've figured it out."

Beth mentions the other interests her students have. "They, you know, they play lacrosse. They work - um, you know, Children's Musical Theater." She later mentions that Scholar's Bowl and music competitions are conflicts that cause issues with students being able to attend the State meet in the spring. The Scholar's Bowl season overlaps with the Science Olympiad season and typically ends the weekend before her regional SO competition. "So, my
kids on Scholar's Bowl have that going on with that." Some of the Science Olympiad students are also on the Robotics teams. "These are amazing, astounding, kids. I'm just really proud of them and they shock me all the time with the amount of stuff they can do."

Another conflict that junior and seniors have is that the school district has a program with the local community college called the Academy. Beth says that during their junior and senior years, the students can go through the Academy and earn an associate degree when they graduate from high school. "The kids that end up doing that hardly ever stick with Science Olympiad their last two years. It's just too much." She says that she is sad to lose them and she misses them, but some of them become those supporters that she mentioned earlier, so they get a small amount of involvement.

In talking about the underclassmen, Beth says, "I really don't put a lot of pressure on them. I tell them Science Olympiad is extra. It's outside Science." Beth says she tries to downplay the focus on winning. She says that she explains to them at the beginning what it will take to win state and go to nationals. "If you really want us to go out there and, you know, win state and go to nationals, that means you're gonna have to prioritize Science Olympiad first." She says, "They all kind of think about it for a few minutes and say 'OK, no' and then we move on." She laughs about this.

As far as how many hours per week they spend, Beth says that is kind of hard to answer. "Towards like January and February, we're probably meeting outside seminar time at least once a week for an hour to an hour and a half or something like that. Just with groups that are building." She starts staying after school or coming in early so that students who need to test builds that need a high ceiling such as the rocket launch [name of event] can have access to the gym. They must work around the sports schedule for that. She has the other kids that are doing
the test events do it themselves. "They meet together, and they make their note sheets. Sometimes they all come to my house and we work on computers and print note sheets, you know, it just depends on what resources they have."

Beth says she does not see students feeling inadequate if they do not do well in an event. "I've never seen that with my guys." She laughs and quotes them saying, "Man, that test was hard." She continues laughing as she talks about how they deal with it. "They shake it off. We just don't put a lot of pressure on it." She tries to just reassure them that she is just happy they are participating. "Anything you do is a plus and, you know, any science you learn outside of school science, to me, is a good thing. It's a win and it will do you well no matter what you go into in life."

She explains to them that Science Olympiad is not like being in a class. "It's not like school where, you know, you're starting at a hundred percent and if you miss this much you subtract, right?" She tells them that in Science Olympiad they start at zero and what they do adds to their score and she shows them tests from previous tournament. She has an example of where one student got $36 \%$ on a test and won first place. "So, they kind of get it after a while especially as they go through a couple of years with it."

## Advice to Those Coaching Science Olympiad.

Beth says that when it comes to the financial burden of starting a team, it really depends on how much your district is willing to pay. "Once you have your lab coats and you have your goggles or if you can borrow them from the school, that's a big start-up part." After the initial start-up costs for non-disposable items there are tournament expenses outside of transportation. "So, it's probably almost $\$ 300$ by the time we pay all the fees, you know, to enter state. And then, if we go to an invitational, some invitationals have fees associated with that. That's just the fees to enter." Beth describes some of the yearly expense for consumables and for new event
materials when events rotate. "Then year to year we try to buy the little kits for Fossils or Rocks and Minerals or something like that. We also must buy the stuff that goes away like the airplane kits and all the balsa wood." She estimates an additional \$200 per year minimum for just replacing consumable materials for the events. So, she estimates $\$ 500$ dollars a year just to keep a team running after the initial start-up expenses the first year. Her teams help pay for this by doing concession stands for their school activities. "Both our high school and our middle school know that we're suckers, and we will [work at] any concession stand they can't get filled. I have very responsible kids and even my Middle School kids can run concession stands. I mean, we must have at least one adult with the Middle School kids. My High School kids have run them on their own."

Beth says that she feels sorry for the small schools and gives an example of how hard it can be to get started especially for a small school.

Like there's a school down closer to the state border. And the girl there was just trying to start it up as a middle school team and, you know, she had nothing. She started with nothing. No kids. No parents. No administrative support. And that's a hard way to go. I think that was a couple years ago because she was - she was desperately trying to figure out what you do. And - and she came to the state meeting where there were all the coaches and she just asked. She had a pad of paper and she went around and asked questions to every coach she could find and, I mean, she was really trying hard. But, you know, without any equipment, without any test files, with, you know, with it - with nothing, it's it's really hard to get going. I mean we started up that way too.

When asked if a group of kids at a school could start a team without a coach, she replied, "I think it's harder for a school to start a science Olympiad team without an adult presence." She says she is not sure if a high school would let a group of students start a team.

## Appendix J: Kelly's Science Olympiad Experiences

## Introduction

Kelly coaches the high school team and oversees both the high school and middle school teams at a private non-denominational Christian academy in State D. Kelly is now serving her third school in that state and has started Science Olympiad programs at all three schools. Each school that she has been at has been progressively larger than the school before. Her current school is pre-K through $12^{\text {th }}$ grade and has a student enrollment of 1,292 students for the 20192020 school year according to the National Center for Education Statistics (NCES). The school's location is classified as "large city". Kelly has taught Physics and is currently teaching Honors Chemistry, Forensics, and STEM Research Project classes.

## History of Involvement in Science Olympiad

Kelly became interested in Science Olympiad when she was in her third year of teaching. She received an email that had been sent out to science teachers about Science Olympiad. Her team's first competition was regionals and at it they qualified for the state competition. "It really hooked me onto it because the kids were so excited about it."

She coached at her first school for two years until that school closed. Then she moved to another private Christian academy and started the program there where she ran Science Olympiad for eight years. When she left to come to her current school, her new school was very interested in her starting a program for them because she had been so successful at her previous two schools. She is currently in her eighth year at this school. That is a total of 18 years

## Perceived Benefits of Science Olympiad Involvement <br> Personal benefits.

When talking with Kelly about personal benefits, it was difficult for her to not talk about student benefits. "I get to expose them to areas that they wouldn't normally be exposed to at
school." She uses the Ornithology event (short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U) as an example of how they learn things that would rarely be taught in a class. This event assesses student knowledge about specific species of birds on the Science Olympiad Official Bird List. Students must be prepared to answer related questions including those about diet, behavior, range, distribution, anatomy \& physiology, conversation, and interactions with humans as well as other topics. Up to $50 \%$ of the test may be identification of species through pictures, characteristics, or calls (Science Olympiad wiki Ornithology). This is much more detail than would be presented about birds in most Biology classes.

She admits to bringing ideas from some of the events into her regular science classroom. The bridge is an example of a project she brought into her physics classroom. For the Bridge event, teams of two students build a bridge out of either balsa or basswood and glue. The span of the bridge must be 35 cms for Division B and 45 cms for Division C. Bridges are tested until they break or can hold 15 kgs (Science Olympiad wiki Bridge). Structural efficiency is then calculated for unbroken bridges. Kelly can use this project to teach about forces and specifically to demonstrate compression and tension which are the two main forces affecting the bridge.

As an example of an idea from a paper test, she mentions the Fermi Question event. A Fermi question is a question where an estimate is made to answer a question that is either difficult or impossible to measure and calculate directly (Science Olympiad wiki Fermi Questions). A classic example of a Fermi question is, "How many licks does it take to get to the center of a tootsie roll pop?" Students are given a series of questions and compete in teams of two where ideally one student in good at estimating while the other is good at calculating and they combine their skills to answer as many questions as possible within the time limit. Answers
are awarded points based on how close they are to the actual number. Kelly says, "I tell them to always pick the most interesting question to bring back to me so I can have fun with the class."

Focusing more on how Science Olympiad coaching benefits her personally she says, "You really get to know the students and the students get to know you." She feels this is of the most benefit when you also have the student in an academic class. When asked if a teacher develops that relationship during the class anyway, she responds that the Science Olympiad relationship is deeper. "Seeing them after school and participating in a program and getting to congratulate them and be there for them and stuff like that - it's just deeper." To explain the differences, she says that once a student who has only had her in class leaves her classroom, they are done with the class and with her. Students she has coached in Science Olympiad are continuously coming to her room to just be there. If she is currently coaching and teaching the students, they feel comfortable coming to ask her questions about things in class as well as things outside of what may be in class. Kelly only teaches sophomore level students and not all sophomores are required to take any of the classes she teaches. Therefore, there are some students that she never gets to meet and teach in one of her classes. However, some of these students do join the Science Olympiad team and she gets to know them through this activity. She thinks the greatest benefit to the student is for them to be on the Science Olympiad team first and then have her as their teacher later. "We just seem to have a better relationship and understanding."

When asked again how all of this is a benefit to her, she responds, "Oh, it makes me feel good that they love science!" So, for Kelly it really comes back to the student and getting them excited about science. Kelly says that is very satisfying for her and its fun. "If we didn't enjoy it ourselves, we wouldn't continue to do it." She says she enjoys going to the tournaments as much
as the students do. She enjoys making all the plans for the team to go to invitationals. "It's like a big puzzle for me in trying to make sure everything works together." Another part of her enjoyment is that she must learn new things when she does not know something about a category. "It forces me to study a little bit and I like to learn."

## Perceived student benefits.

Kelly sees confidence as a major benefit for students. She credits the number of categories of events for offering a wide range of opportunities. "There is just something for all of them and their confidence just grows within themselves." She sees this as especially beneficial for students with learning difficulties. An example she gives is her daughter who has trouble taking written tests but thrives in the building aspects. "[She] very much pays attention to details and it makes her feel so much more confident. Especially when she wins those categories." In response to the question about whether Science Olympiad participation increases test scores, she says that a lot of her Science Olympiad students are top academic performers anyway, so it is hard to say. However, for students with learning differences she thinks there is a score increase just because of self-confidence within themselves. Regardless of whether test scores increase, Kelly feels that Science Olympiad has a large impact on student knowledge. "It exposes them to topics we wouldn't be able to cover in school."

Kelly says that students often think that science is confined to a classroom. "This kind of expands their experience with science and for some it really creates a love for science that they would not have had." She gives the example of her daughter who loves the building events. "She would not have gotten that in her class at all and so she realizes that there's more to science than just academic books and paper and maybe a lab, you know, kind of thing."

Commitment is another thing Kelly sees Science Olympiad teaching students. "That maturity of staying committed to a team or understanding once you give your commitment you
cannot decide to go to something else because it is more fun." She says this is harder for the middle school students because they are so young.

Kelly likes hosting invitationals and she thinks it is an important process for the students. She says that students learn their category more when they are hosting an invitational because she assigns students to an event, and they get a list of everything that is needed for that event. They must set up everything for the event sponsor or test proctor beforehand. "They tend to dive more into the rules when they're having to set it up versus when they're having to study." She says that it is very common for students to ask her, "What kind of calculator do I need?" She says it is hard to get students to read the fine points of the rules and they want to rely on her too much. However, if she can put them in charge of setting up events, then they take responsibility for understanding the rules of that event and it makes them better competitors in that event.

Learning research skills is another benefit that Kelly sees. Students generally must learn their events on their own. So, they must take responsibility for their own independent study. Kelly sees this as an important skill to learn in preparation for college. She says that it teaches them how to find information that they know is going to be on the test, but that the professor did not discuss in any detail. It teaches them how to take notes over the information they find.

She gives Forensics and Write It Do It (see Appendix U for an explanation of Division C events) as examples of events that improve writing skills. "They have to write such a deep analysis and having the skills to break everything down and write it well because they get so many points for what they wrote, I think is important." In Forensics, half of the score is earned through teams of two students conducting a series of laboratory tests on provided evidence to solve a crime scene. The other half of the score on this event is based on the Crime Scene

Analysis essay which the team writes based on the results of the laboratory tests (Science Olympiad wiki Forensics).

She comments that students do not think these are going to be hard categories. They especially think that with the Write It Do It event. In this event one student is give a built structure and must write a set of instructions for how to build it. The second teammate is given the written instructions and a set of unassembled materials and must recreate the object as accurately as possible (Science Olympiad wiki Write It Do It). "It's so funny because you don't think that would be a hard category and just writing down how to build something, but it's amazing when they realize how many steps they forgot to write down."

Kelly says that students grow intellectually. Sometimes for a tournament she will need someone to compete in a category or two. There will be students who want to be on the team and Kelly will ask them to try a category even though they do not know anything about it. She says that often they find they love it. They will come back to her saying, "Wow! I never knew anything about this!"

Kelly explains how she recruits and constructs her team to benefit the students as much as possible. Currently she has three high school teams. She says at the beginning of school she does an informational meeting with the students. Then she talks to the parents during orientation. Kelly says most of the recruiting is done by the students. "They usually are the ones that are recruiting and talking to the kids about how much fun they have when we go on trips and stuff."

To construct the teams at the beginning of the school year she puts her upperclassmen on the A team. She then runs the $\mathrm{B} \& \mathrm{C}$ teams as mixes of lower classmen and new recruits to cover the event categories the best possible way. She likes to give preferences to her seniors
because it will be their last opportunity to go to state. "So usually, it has to do with how well they've performed and then their grade level." She also considers what categories the students choose as preferences. "I do have an A team, but if I have an open category, and I have somebody that's never competed before but wants to do that one particular category, they may make it on the A team just because nobody else would step up and do that category." She says that with the more inexperienced students, the team captains work with them to get them prepared.

Kelly runs her teams with two captains per team. The captains are upperclassmen and usually members of the "A" team and have competed before. Each team votes on who they want to be their captains. This means that for the B and C teams, the captains are most likely not competing with that team. This structure provides opportunities for several students to develop and practice leadership skills.

This three-team approach is for invitationals. When it comes time to decide the competition team for regionals or state, she says she looks at how the three teams performed. She explains that if a person on team B or C has placed first in a category, then she may pull that person onto team A. "I'm going to take my top winners as best as I can and combine the team that way."

Having a class hour for Science Olympiad is not just a benefit for the coach, but also for the students because they do not have to sacrifice another school activity in order to participate in Science Olympiad and the other activities are not forcing them to sacrifice Science Olympiad.

## Workplace and community support.

At her first school Kelly mentioned that she received emotional support from her principal, but that was it. The school did not have the means to help financially. The school was in a low-income area and it stretched the parents to just get the kids to school. She also did not
have any colleagues or parent volunteers to help. When she asked to start the program, her principal told her, "Sure, give it a try, but you're going to have to do it all on your own." So, she went into the program not expecting any extra help.

Her second school was the same way with support even though they were in a more affluent area. "It wasn't until we actually had some success that we felt like we had a little bit more school support." She was able to host her first invitational there, the team had raised all the money themselves to host it.

Kelly describes emotional support as people saying, "Good job!" or "Congratulations". Emotional support also came in the form of knowledge that she could have use of facilities and other things that she needed. "As long as it didn't require asking for money, they were open to us being able to do it."

When she came to her present school, she was a known winning Science Olympiad coach. They liked it that she had taken a team to state. The school was building a STEM honors program, so they liked the idea of bringing in another competition science team. "They're very competitive there. So, they like those wins and they like the thought of a team being competitive." She says the school was excited about bringing in the program, but the support was the same as it had been at the previous two schools. It was not until after she had been there a couple of years that they offered to pay her a stipend. Then two years ago she asked them to give her a class for Science Olympiad and they did. "I think that meant a lot to me that they were willing to build in this class and let me have the class."

As for support from her colleagues, they just give emotional support. "They know it's a science competition, but I don't think they really understand everything that's involved in it and they're not willing to volunteer to help." She says she has had some middle school principals
travel with the team in the past, but not science faculty. "They're very excited that we have something out there for the kids. It's just that it's my job not their job." The other faculty are extremely helpful when the students go and ask them for help. Colleague support is not limited to other high school teachers but includes middle school teachers. She has had a hard time keeping a coach for the middle school team. They are on their third coach in six years. "For my high school program to be successful, I need my middle school program."

At her second school she had more support from teacher volunteers. The Spanish teacher even helped along with the science faculty. She also had a lot of parent volunteers. However, this is not true at her present school. She had one parent who did come in and coach the builds. She says that it is nice to have parents that have specialized STEM knowledge be able to help, but she is OK without the specialized coaches. "Sometimes I worry about are they telling them the right things. Are they talking about the aspects that the kids need to study?" Where she really needs and appreciates the parent support is in keeping the kids committed. She says that her program is competing with all the other programs for the student's time. Students have other school functions as well as things with friends that they sometimes decide they would rather do. Kelly says, "It helps there when you have that parent support that they just keep the kids committed when they're being pulled between different department."

She did not mention or give any examples of community or business support.

## Perceived Challenges of Science Olympiad Involvement

## Personal and coaching challenges.

Kelly says that the biggest drawback for her normally is having to teach the students about responsibility. She says that it is more of a problem with middle schoolers but students must take responsibility for knowing about their events. "They expect me to know all the little details of the rules." So, she must get them to read them and understand them on their own.

Because her family is mostly all involved in Science Olympiad, she does not experience time away from family as a particular drawback. She says that her husband was more involved when she was at the two smaller schools. Now that she is at a larger school, he is less involved. Her youngest child likes to travel, so she sometimes takes her with her on trips. Currently because she has a class, she only holds extra practices with her team every Wednesday for an hour. They have a workday right before competitions, and they usually meet once a month for lunch.

Kelly makes a strong distinction between the terms club and team. Science Olympiad is classified as a team because at her school clubs do not compete. This affects how the group is viewed. Kelly explains, "When you're treated as a team, it's a little bit higher stature because you're considered an official team and we're listed as an official academic team in our catalogue." However, not all teams are treated equally. "I come second to sports." If there is a sport or performing arts conflict with any students on her team, she loses those students for that tournament. "We are a big fine arts and sports school, so I do come second to these."

## Perceived student challenges to participation.

Kelly does not feel that the team gets the recognition it deserves. For example, she uses the recognition given to sports teams. "Anytime a team makes it to state, we have a state walk where everybody's pulled out of class in the hallways and they play the school song, and the team walks through the hallway with everybody with the hallways being lined." She says that also happens with regional playoffs, but usually only with sports teams and not with academic teams. The mock trial team gets treated a little like a sports team sometimes, but the other organization that Kelly regards as being like Science Olympiad is Future Problem Solvers (FPS) but it is not recognized. "And the kids feel that," she adds.

To get some recognition for her team, Kelly is fighting for graduation cords. She says that at her school letter jackets are not as big as they used to be so she would prefer the graduation cords. "I've kind of been trying to fight that battle and have it specifically for anyone who's been on the team for their four high school years."

During the pandemic restrictions, the main issue students have with Science Olympiad is the virtual format. "It's really hard to get kids enthusiastic about logging onto a computer and taking a paper test when they're used to doing some things hands-on." She says the students disliked not being able to leave the school or their home to do Science Olympiad competition. Part of this was because the students felt that sometimes the other schools weren't being completely honest when testing online. Kelly says this is "because it was really easy for a kid to have his phone right next to him and be able to look up an answer or something." She said she was a real stickler for the rules, but when the students got their results back and they had performed very poorly compared to other schools it made them feel like other schools were not following the rules as strictly.

Invitationals provide practice for the regional competition, so Kelly feels that it is important to attend as many as possible. However, each invitational incurs a travel expense. Students must pay their own cost. She says that even though her school is in an affluent area of her city, they have students come to the school on scholarship. Kelly has to find scholarships for these students to be able to travel with the team because often the family is doing all they can to just get the students to school. "If you don't travel and go to any invitationals, it really hurts your chances at the regional competition to be able to do well. You really need that practice of these invitational."

Even though her school is in a large metropolitan area with other schools that have Science Olympiad teams, Kelly's team must travel to attend regionals because none of the other schools in the metro area are willing to host invitationals. Pre-Covid Kelly would take her team to invitationals in her own state as well as State C and another neighboring state not included in this study. Therefore, travel could become expensive.

Student's constantly have conflicts with other school activities. Kelly feels this is a challenge for the students because they like so many things. Because Science Olympiad competes from October until March, it always overlaps with some other activity. The fall competitions are hard for the football and band members to attend. In the spring she has issues with the spring musical. Sometimes the spring musical performances conflict with state.

## Advice to Those Coaching Science Olympiad

Kelly's advice to coaches wanting to start a team is to start small and not get overwhelmed. Unless the school is agreeing to cover the national fees and the fees for invitational tournaments as well as a small budget for supplies, the coach will need to have some ideas for fundraising for the teams. She charges a $\$ 25$ team membership fee to help cover the national fees. Then they do a large fundraiser selling bottled water during their Church's large Christmas production as well as at some smaller events during the year. She also recommends that coaches take advantage of the Summer Institute or Summer Workshop put on by the national organization each summer in Arizona. "That really helps break down all the different categories and creates a better understanding of it."

## Appendix K: Laura's Science Olympiad Experiences

## Introduction

Laura was one of the teachers who began the program at her private Catholic Elementary School for grades PK-8. The school locale is characterized as City, large. School data for the year 2017-2018 gave 186 total students and 10.3 teachers with a student to teacher ratio of 16.3. Marie coaches a team composed of grades 6-8. Enrollment data for those three grades for the years 2015-2017 total 66 students. Race/ethnicity numbers for the entire school report 63 White, non-Hispanic; 55 Asian; 51 Hispanic; 4 Black, non-Hispanic; and 3 Native Hawaiian, Pacific Islander. This is the smallest Middle School discussed in this study.

## History of Involvement in Science Olympiad

Laura is a retired social studies and literature teacher who became involved in Science Olympiad when the head coach at the time asked her to coach the Road Scholar event. There had been a volunteer coaching that event, but that person moved and someone needed to step in and take over. Laura thought to herself, "Oh geez, they're really gonna know how stupid I am, sure." Laura coached just that one event for two years until the head coach got sick and resigned. Then she took over as head coach and remained as such for 13 years until she retired in 2018. Since then, she has been helping the head coach and is still coaching the Road Scholar event.

She was Regional Director for eight years. During that time, she decided to allow the top six teams from the region to go to state. "At regional we have like nine to twelve - twelve schools, you know, so it's like 'Come on, do one through six'." She also started the practice of running an invitational simultaneously with the regional tournament. Originally, for regionals, the school brought one team and their alternates. "I started out with having Mystery Architect as an extra event and I allowed only the alternates to go to that." She says that it gave the alternates
something to do. Then she decided to make an invitational where schools could bring a whole team of alternates. "The alternate team was scored totally separate from the regional team and it worked out pretty well." This format is still being used by the current regional director.

## Perceived Benefits of Science Olympiad Involvement

## Personal benefits to the teacher.

When asked what defines a successful team, Laura says, "Oh! We don't take last place." She laughs. "I'm not really kidding. There's a saying about second place not being the best place. I don't care. When I look at what they learn and what they know when they walk away from this, top ten I'm happy." However, she does indicate that she expects top ten out of her team. "If they are below the top ten at Regional, that's the time to have a pow-wow with the coach and find out why they didn't make it in the top ten." She explains that if she is going into State or National competition with some team members scoring below the top ten, she will try to get them and maybe their coach extra help to bring them up before the next competition. "I don't want to be last. That's all. Middle of the road is okay, but last is not."

Laura does not receive a stipend. She says that there was an exception for the years that she took the team to the national tournament. The priest and the principal in charge that year got a thousand dollars together and gave it to her for going to nationals. She says it was because that principal and that priest thought to do that for her. "They thought and we never got it again. Never." However, she says that she is fine with that. "I didn't do it for the money."

Laura talks about how she always enjoys attending Summer Institute. "You go and you look at the new events and you talk about pitfalls with the rules and the new events." In her state this is organized by the state director although there is a national one that everyone can go and attend. She says the state director and some of the event sponsors make the presentations of the new events. They will also present the old events so that all coaches including new ones have an
idea about all the events. "It's just a session so that by July I know what events are going to be next year and for me what coaches do we need to start looking for?"

## Perceived student benefits.

Laura sees the opportunity to travel to tournaments as a benefit to the students. "When I started -that was the first thing in 2005- I said we need to get these kids to some kind of competition." She then began looking for invitational tournaments which were not common near her location. These practices get the team ready for regional and state. She thinks that winning state and progressing to nationals is a special benefit to the students who can do that. She took her team three years in a row from 2007-2009. "It's a wonderful experience and it's great for the kids." However, in 2010 she says that the students just thought it was a given that they were going to the national competition and they did not put in the work needed. It was not until 2014 that her team was able to make it back to the national tournament and that was the last time they went. "We had enough participation for our State to have two teams go to Nationals but let me tell you the prep is one thing," says Laura. As stated previously her main goal was to have her team prepared enough to not come in last. She says she told her team, "There's a lot of competition here. Let's just have a good time." The team did get some recognition at the national level. "We got a first in Bridge at Florida and we got the Spirit Award when we were in DC." (Short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U.) Regardless of how they place and whether they are at nationals or an invitational, Laura expects her students to show good sportsmanship. When they go to tournaments, Laura expects the team to clap for everyone. She tells them that they know how tough they worked. "They put in a lot of work, and they deserve to be acknowledged."

Through Science Olympiad participation, students learn more than science. In the process, Laura sees them discovering unknown abilities. "I can tell you a story of a young girl of

Vietnamese heritage," says Laura. "Oh my gosh, could she draw, and she wanted to do bugs. At that time, the event was called 'Don't Bug Me', so you know how long that was." Laura relates that she did not expect too much from the girl and her partner. She thought, "Well, we're just gonna write that one off". Laura continues, "Well, you know what?" Laura continues, "She took first place at State." Laura said that the girl came up to her later all excited and said, "I didn't think I could do anything but draw."

Laura continues with another instance with the entomology category and another girl who really struggled in school. "Especially in math she struggled, but she was good at bugs! I don't know what it was. She just got it," says Laura. "And it's those kinds of things that you watch. The ones that are the underdog or they struggle in the classroom and yet they find that one building event or that one thing they do really well in."

Laura says, "I've had kids that are great builders. That's all they can do is build, but they do it well." She explains that it's hard when she is trying to put together a team of 15 kids to cover 23 events and there are a couple of kids that are only good at one event. "But you're going to sacrifice a little to make sure those kids that are really dedicated in only one or two things have a place on the team."
"I had one. She was going to be a lawyer," says Laura. "Well, now, she's going to be a pediatrician. She's in her third year. Laura keeps in touch with what her former students are doing via their Facebook posts. "You're going to have probably one or two that are going into some science or engineering that they weren't going into or didn't think they could do."
"I think," says Laura, "go back to the kids that go to Nationals, you know. They take charge. They have to take charge of this. It has to be them that deals with it and makes it work, you know." She gives the example that if a student is not coming to practices or doing their part
in preparing for a meet, their teammates will hunt them down and tell them that if they are not going to put in the effort, they will find someone else who will. "So, they take charge of it. They take ownership and so that's what Science Olympiad does. It allows them to take ownership and with ownership, you know, we become good leaders." She says they gain confidence and refers to the girl who only thought she could draw but now she can do things she did not know before. "That creates more confidence and with confidence you become a good leader.

Laura says that the three years that they went to nationals she had a group of seven that had started in $6^{\text {th }}$ grade. In that group there were four girls that set nationals as their goal. "Let me tell you they ramrodded everybody." She says that she and the other coaches only had to present the event material to the students and give them incentives. The students did everything else.

Laura sees Science Olympiad being of particular benefit to her students because of the way her small private school functions. Every teacher teaches two subjects. The teacher who started the Science Olympiad team was a Religion teacher and that was all she taught until everyone had to start picking up a second subject. Then she wound up teaching science. Laura says that the school has rarely had a person who was qualified to in science. The school is set up to where one teacher teaches social studies and literature, another teacher does religion and English, and a third teacher handles math and science. "That's the way our school is," says Laura. She says that typically the person teaching science is actually a math teacher and it is often not a good match. "I mean, it's interesting. The math teachers don't want to teach science."

Therefore, the opportunity for the students to learn science outside of school with mentors that spend time explaining topics to them is a great benefit to the student. "When we started doing Science Olympiad, our science scores started shooting to the top. We went to Excellent rating in State where we hadn't been before." She says that even the students who eventually say it is too hard and give up on the competition still learn some science in the process. "That is why we don't limit who can be on the teams." Laura sums up her philosophy about not being too demanding on the students or too selective on who can participate. "They don't have to do this to fill up their hours. You know, they can fill it up with sitting and playing with their machines."

Laura sees the students learning more than science content. "I've noticed that when we would do our state history or I would do geography with them and we do latitudes and longitudes, those kids that had done Road Scholar would help the other ones find the latitudes and longitudes." She says that Road Scholar also teaches students about polar extremes and how to use coordinates. She says that over the years different things from Experimental Design have related to various things in her history class. Laura says that elementary and middle school are each in their own little worlds. "I mean, think about it. Middle school blames primary for not teaching certain things. High school blames middle school for not teaching." She adds that college blames everybody, but she agrees it is true. She says that her $6^{\text {th }}$ graders do not know the states and capitals or the presidents. She taught both of those when she was teaching $5^{\text {th }}$ grade. "They don't teach them anymore."

Throughout the year, the pairs and trios are meeting with their coaches on different nights after school, but Laura feels it is important for the whole team to come together. She says that they do team building at the beginning of the year and at the end. "We do team building partly
because it allows each group to know what the other groups are doing, and the kids love seeing the building. Laura calls the builds "target shoots". She says, "You know, one day it works perfectly and the next day it won't even go. So, you don't know what's gonna happen with that, but they love watching that. They have two mandatory practices. One practice is before the regional meets and one is before state. "We spend from about 9:00 to 1:30 and we eat lunch together, but they all work and they all help each other study." For the afterschool practices the coaches will sometimes bring a cheap pizza or a snack because the students have been at school all day and may not get home until 6:00. "...our coaches are good at bringing in food for them. If it's not a snack, we get Caesar pizza. They're only five bucks, you know, we can afford that...". She says that helps the kids get closer because they stand and talk to each other while they eat.

According to Laura the cohesiveness of the team forms when they are doing things together. When she was allowed to stay overnight on a trip, she took the team to an invitational in State D. She says it was great to go there on Friday night, get up on Saturday night for the tournament, have dinner, and then come home. Now that she cannot stay the night, she takes her team across the state to a different invitational. They must leave at 4:00 in the morning and will not get home until after midnight, but she feels it is important that they have some time after the tournament. She takes them to a place where they can go through a buffet and get tokens so that they can play games after they eat. Laura mentions how the bus trips are where she really sees the grades mixing. She says that they are riding together, and they are playing together. "Sixth graders tend to stay with sixth graders. They really do. They're just not there yet." However, she sees that by the end of the year, the sixth graders have gotten closer to the older students. "They watched them and everything and they were pulled in, you know. They make that
connection with the previous $7^{\text {th }}$ graders and so as $7^{\text {th }}$ and $8^{\text {th }}$ graders they're together." Laura indicates that the bond becomes somewhat like a family. "The Science Olympiad kids are pretty protective of each other when it comes down to it. Absolutely, they protect each other."

When asked how she knows they are enjoying it, Laura says, "If they meet once a week, you don't do that because you're forced to. You do that because you want it." She also does not see anyone being forced by their parents. She says that parents support them very well, but do not force the students.

Several years back Laura served as the director for the regional meet in her area. She explains how she used the opportunity to make some changes that have continued to the present. "I started out with having Mystery Architect as an extra event and I allowed only the alternates to go to that. It gave the alternates something to do that day." This meant that a school could plan to have alternate students attend with the team in case there was a no show of a team member, and the alternates would not just be sitting around all day if it turned out they were not needed. "Then I decided to turn it into an invitational. So, if a school wanted two teams, they registered two teams. They paid the money to the national for the second team and they could bring in a second team." For the first two years she did it, only her school and another took advantage of it, but it caught on and is still being done today. "It allowed our kids to keep trying and some of them were good. They just didn't have- you know, they had to pick the better one for the team."

## Workplace and community support.

Laura has a situation quite different from that of a public school. Being attached to a parish, the church community in large part feels it has a stake in the success of the school whether they have children attending or not. "They just donate. Somebody will pass away and the family will donate the money to the Science Olympiad." Laura explains that she doesn't have to ask for community donations. "That's because I've established Science Olympiad and
because we've done well. It's been about 17 years. All those kids and all those parents have gone through it. Our coaches have gone through it. Our coaches donate." This attests to the power of alumni maintaining a connection to the school and the team. However, there is even more to it than that. "When we went to nationals, there were people that didn't even go here but their cousin did, and they heard we were going to nationals and they wanted to give us money." Laura does say that in the early days she did do some fundraisers with her team. "I don't have to do fundraisers anymore because we've got a nice nest egg." Laura implies that some of the large donations her program has received may be in forms that pay into her program at regular intervals. However, she does not divulge specifics about her previously referred to "nest egg".

Laura says that when the team first started, they did ask for a fee. Then people started giving money to the team. She says that many of the coaches give money as part of their tithing. "I was very cautious on how I spent it." She says that she has enough money built up to take care of supplies for the Science Olympiad events so she tells the coaches that she will reimburse them. However, she says the coaches do not ask for reimbursement. When they travel to invitationals and must get a bus, they do charge the students 50 dollars to cover that. She pays for their dinner, though, out of her fund because there is enough there for that. She says that when they go to nationals, she starts begging for donations to cover that expense. She says she is not good at begging for donations, so she gets other people to do that for the team. She says that in the past people have been very good about donating.

A tradition of success has been a major factor for Laura's ability to garner administrative and community support for her team. Financial support comes in from donations by parishioners and even from people who are not directly connected to the school but have heard that they have a great team and want to support their continued success. Word of success is spread by the
students talking to others. The team's activities and successes are published in the parish newsletter that members of the congregation see and it also gets sent to people who were at one time part of the congregation but have moved elsewhere. For a time, articles about the team were also published in the city paper, but the city paper has closed.

Even though Laura functions somewhat independent of school finances, she sees administrative support as being important, especially under certain circumstances. "Well, I think if you're the only coach, you have to have your administration," says Laura. "I think you do have to have a little support from your principal. I mean, my gosh! It's nice. Let's put it that way. It's really nice." She relates a conversation that she had with her principal who was concerned that Laura was going to quit coaching Science Olympiad now that she was retired because the numbers were low, and they were having so many problems. The principal was aware of the need for support for the new coach and that Laura was the best person to provide that support. "I'm not going to quit. I wouldn't do that to this coach. It's a struggle for her right now emotionally and all I can do is try to support her. Knowing that she's got that, she's going to do it."

She tells how she recruits parents. Her school holds registration for the school year in July. All of the parents are required to attend so she goes around to them and asks, "You want to be coach? These are what we have available. These are the events we don't have coaches for." She says that some of the school alumni come back for that event as well and she has used this approach for years. "And that's when I got my coaches and that's when we still get our coaches now."
"You have to ask parents directly," says Laura. "I've had two coaches that started when their kids were in Science Olympiad back in '05." She describes how one volunteer started
when his child was in kindergarten, and he did not have any kids in Science Olympiad. He coached the whole time his child was in school and is still coaching. "He's an engineer and, even though his work schedule is very busy, he does one after the other two hours a week and so that is the dedication. I think having the support of your parents far exceeds having administration." Her philosophy is that administration has enough to worry about without having to be involved in club activities. She feels it is her job to follow the rules so that administration does not have to worry about Science Olympiad. "But we need the support of our parents because if we don't have that, those kids aren't going to get there on time. They're not going to get picked up on time." She also says that when her students do need things for Science Olympiad, the parents are pretty good about getting things for them, so she has that support from them as well.

There is even a more important way that the parents and community members support Laura's team. The team boasts some 20 coaches almost all of them parents or community members. She recognizes that it is quite a unique situation and that most of the coaches at other schools in her area do it all alone. "If I was the only coach, I don't know how I would do it." She tells how her situation came about. "The lady that started Science Olympiad and myself, we're not science teachers. So, we had to have help. So, we started by finding parents of these kids and that's why we're set up that way." Laura says she is fortunate because of the local aerospace industry in her area. "We have a lot of people that are engineers. And one thing about the Asian community is most of them will volunteer if you ask them, but you must ask them. I've had very few tell me no." She explains that the only parents who turn her down are those who feel that some of the students may not understand their accent. Laura talks about
maintaining her coaching team over the years. "It is difficult to find 23 people that will meet with them once a week and really meet with them. Your coaches have to be dedicated."

Laura's husband was the Ornithology coach before he passed away. She says that he did not know anything about birds beforehand. She could not find anyone else to coach, so she told him, "You know, hey come on. You're at home. This will be good for you." The Ornithology event assesses student knowledge about specific species of birds on the Science Olympiad Official Bird List. Students may be asked questions about facts including diet, behavior, range, distribution, anatomy \& physiology, conversation, and interactions with humans as well as other topics. Additionally, up to $50 \%$ of the test may be identification of species through pictures, characteristics, or calls (Science Olympiad wiki Ornithology). She says that he spent hours prepping to teach the two girls who were doing that event. She says that the coaches present a lot to the kids to give them deeper understanding in each one of the events. "And I have a lot of retired teachers. They're still with us. One told me that they would stop when I stopped." Laura laughs, "It's like, 'Oh, OK'." When asked if that was a possibility now that she is retired, she responds, "No, I'm not going to quit."

As Laura has already explained, her school is small with teachers already teaching multiple subjects, so the pool of teachers with expertise related to STEM is limited to one or two at most. They rely on parents and community people to provide some of that expertise but help also comes from a few of the non-STEM teachers. "With us, we have a lot of coaches that we can just bat around with each other. There's some of them are the teachers at our school. I mean, we had the music teacher even helping us." Laura does further indicate that even though you can manage with mostly parent and community support and only moderate peer and administration support, it is still important to know they are behind you. "You have to have support from your
school, or you might as well not even bother with it. We were lucky because it didn't matter if we had that support or not. I think at each school it's different."

Laura does not relate a positive experience when it comes to receiving emotional support from most of the teachers that are not STEM or otherwise involved in Science Olympiad at her school. She has an experience where a third-grade teacher said to her, "You know, this school isn't only about Science Olympiad." She responded with, "No, but we're going to National so let me tell you that's putting our little school on the map when it hasn't been for 40 years." She thinks there may be a little jealousy because Science Olympiad gets attention. "But look what we're doing for the kids, and we didn't seek out that attention. We're not."
"Absolutely!" exclaims Laura when asked if emotional support is important to her. "Especially in 2014 it was." Laura has a specific story of how one year she got special support from her administration.

In fact, we did not know that the Priest was going to come. I mean, he kind of was real[ly] low-keyed about the whole thing and the Principal kept asking me when we were going to Mass on that Saturday or Sunday because, you know, we have to go to Mass. So, she was like, "What are you doing Saturday for mass?" And I kept saying, "Well, you know, I'm working on it. I'm trying to get a priest to come. If there'll be a priest that'll come, you know, they'll just say Mass there." But, I said, "I haven't figured that out yet." My other choice was going to the Basilica, you know, and I said, "And we may go to the Basilica. We will have to go at the 6:00 a.m. Mass on Sunday but that's, you know, I don't really know." Well, she was trying to figure it out because the Priest was coming and he needed
some information, you know. Well, it ended up that morning he walks in and it's like "Oh, thank God!"

She laughs, "But he was so excited that he flew in just to be with us that day and to see what it was like. And, so, he went around to all of them, and we just had a great time, you know." Her body language and laughter reveal that this is a particularly fond memory for her. "That was the first time a principal ever went with us to Nationals and that was really something to have both the Priest and the Principal support us in that way."

## Perceived Challenges of Science Olympiad Involvement

## Personal and coaching challenges.

Laura says that the first step to a successful team is getting a group that wants to work together. "And then you have to be there to support them and after that they have to know you're there to support them." Laura thinks that high school students do not rely on their coach as much as middle school students. She explains how the coach that started the Science Olympiad team at the high school which her middle school feeds into was the sole coach. "He did it all himself." She says that he gave the students the rules and said, "There you go. Figure it out." He was there as an advisor. She says her students rely on the coaches to not only present material to them but to help them organize it. She tells her coaches that they cannot just present material to the students while they sit and listen. The coaches must sit down at the computer with the students and build the binder with them.

She says coaches need to continuously do motivational things. "I don't think some of the coaches understand that you have to motivate your kids all along." She says she tries to make cards of a place they might visit if the get to go to nationals. She uses the example of the year that the national competition was held in Florida. She describes that she made a card with Disney World and Mickey Mouse on it with the dates of the tournament and she wrote on it,
"This could be you." She says the team made slogans and little chants."And I think all of those - that motivational - is part of this. You must motivate the kids." She says that once they know you are excited, they get excited.
"Never did that," Laura says very strongly when asked if she designated one competitive team with alternate teams. "One team. They were all one team." Throughout her years of coaching, Laura managed to maintain a team of around 30 students consisting of about one third of the middle school population. She usually ran her kids as one big team while attending invitational tournaments and did not separate out a team of 15 until it was time for regional and state competitions. Most of the invitationals she attends do not have teams at all. As many students as want to can enter each event. Laura mentions one invitational tournament where they allow up to three teams per school for each event. The regional and state tournaments only allow one team per school.

Determining the students that are going to make up that one team can be challenging for a coach. Laura explains, "You know, at an invitational everybody can go. Everybody can go and everybody can - can do it. So, that one we don't worry too much about, but when it comes close to regional, I start asking [the coaches], you know, who are your strong ones?" And it'll be that one or two that we have a struggle with, you know, where they're not picked by anyone else, but they're picked in this one event." She then has a dilemma of how to let as many of the kids who are best in their event compete while only having a 15-member team. She implies that having kids that are top in multiple events is not as common as one might think.

In explaining how she recruited students Laura says she did not hold a beginning of year organizational meeting. Her strategy was to write a synopsis of each of the events and take it around to the different classrooms. She told the students to take it home if they were interested,
talk to their parents about it, and then bring it back. She describes how she handled it if students do not return the form, "I was never above grabbing the kid and saying, 'This is ridiculous. You should be in this'."

She says that even before COVID student numbers on the team dropped. "I don't get it because there's nothing really changed." She says that the event coaches that worked with students on each event are the same. Only the management has changed. Laura thinks that the drop in students with the change of the head coach could be related to the motivational aspect. She has talked with the new coach about needing to tell the students, "Come on guys, let's do this. You know, I really want you to do this." The new coach has responded, "Well, that's not me." Laura insists, "No, but it must be you because they have to know that you want it for them.

In discussing the challenges that COVID has created, Laura says that they did not do Science Olympiad last year because of COVID and this year was slow getting started because it was difficult to get the students involved. "The momentum is lost", she says. "Next year, looks a lot better. We lost several coaches who decided not to come back. So, we did not have 3 events covered. That affected the outcome."

Laura talks about the challenge of conflicts with other school clubs. "We have to schedule all around all of those things and the smarter kids are in all of those, you know." She says it comes down to if Science Olympiad is what they want to do then something has got to give because the other organizations want the students' time just as much. "But we do work with them. I mean, you know, especially around sports. We work with them. Make sure that they, you know, can do sports, and can do this."
"I'm a good organizer. That's what I am, and I could find the coaches." She says that it is harder now that she is not the head coach because all she can really do is give names to the head coach.

She says that she has only occasionally had trouble finding coaches. They had the most trouble keeping coaches in 2019 and early 2020 because people got sick even before COVID became an issue. When Laura has lost coaches over the years, she handled it by continuing the meetings with the students and filling in herself until she can find somebody to take over. Sometimes she can get another coach to take on a second subject. "It is difficult to find 23 people that will meet with them once a week and really meet with them once a week." She says that it is best when she can get and adult from the community, but sometimes it is school alumni who are in college. She finds they are not always reliable. She says that if the team is going to go to national the coaches have to be dedicated a well as the students.

When asked if she sees coach burnout as a problem, she responds, "I am." Which is surprising because she is so enthusiastic in talking about her experiences. "I mean, I'm tired. I am. And yet, am I gonna quit? No." After 17 years of coaching Road Scholar the national organization had decided to retire that event. "Well shoot! Now where am I gonna do?" She says she has looked at the events and has decided to try aquifers. "I figure I can do that one." She says that she has struggled a little more now that she is retired. She explains that when you are working even if you do not feel god you still get up and go to work. However, now that she is retired, if she does not feel well sometimes, she will ask herself, "Do I have to? Do I want to?"
"No, I'm not a science person, but I sure appreciate every science person out there just like I appreciate every teacher out there." She says that they do not get paid what they need to get paid, but they are doing it because they are good at it. "They're doing something good."

She says that it is a lot for a head coach and that she did not really care because going to national was a lot of extra work. "I mean it was a total full-time job after my full-time job to get ready for nationals." She says that you must plan food, rooms, transportation and some kind of entertainment.

## Perceived student challenges to participation.

Science Olympiad participation is a large time commitment for the student. "If they want to go to Nationals," says Laura," they're going to eat and sleep and breath that almost." She gives an example, "If you've got seven of them that are in most of the events, you know, each of them are in like four events. You've got the events covered with somebody and they're studying those." She expects them to spend an hour per event studying or working at the meeting and then she expects them to take that times four at home during the week. That is a huge time commitment. "I mean, if my kids only spent their extra time on Science Olympiad, we'd be going to Nationals because they have everything they need to get to Nationals through our coaches."
"But we have to fight with our kids do everything." Laura talks about Chess club, Scholar's Bowl, and Religion Bowl competing for her kids' time. "And so sometimes it's like choose. What do you want?"
"And the kids have to be hungry for it," says Laura. She talks about the two girls her husband coached in Ornithology. "They were hungry for it." If a team is going to nationals, it takes dedication from the student. "Those kids have to want it and it takes the kids to work together." She says that it can be hard to get $6^{\text {th }}, 7^{\text {th }}$, and $8^{\text {th }}$ graders to work together. The pairs
for each event have to trust each other. "You can have two really smart kids, but if they're not going to work together, they're not gonna make it. This is because a successful pair has to split up the work between the two of them.
"Honestly, our kids aren't the math and science kids." She continues, "Don't misunderstand. We've got some good kids - some smart kids. We also have some just average kids that enjoy this." Apparently, they enjoy it enough and are smart enough to have gone to nationals a few times. "Think about it," Laura says, "Anybody that wants, you know. If you want to accomplish something, I don't care what your struggles are, you're going to accomplish it if that's what you want to do and that's what they have to want."

Laura also talks about the expectations for competition being different in other states. "If they only had Science Olympiad to do, we'd be going to Nationals frequently," Laura comments referring to her earlier statement about having to fight for the student's time. "You go to those Eastern schools or even, you know, like Troy High School out in California. That's their one thing so everything is based around that. Ours isn't." Laura thinks that the founders of the Science Olympiad 35 years ago did not expect it to become what it is today. She asks herself if "the motley little groups" here in the Midwest can ever beat the bigger teams further east at nationals. She does not think so. She says there is a whole different feeling on the east coast about jobs and work ethics compared to her location. "We're so much easy going, you know, and they're - they're like dog-eat-dog." She says that you do not realize it unless you have lived it or seen it. So, for her it is not about the prospect of having a team that can win or place at nationals. "I think it's a great way to get kids involved in every part of science so that's, you know, that's why I do it."

The individuals on her team meet once per week with the mentor for each event they are in at a time the mentor sets. This means that students who are in several events will meet with different mentors during the week. "We post that, so everybody knows who's meeting on those days." This precludes the kids having the excuse that they did not know when the meeting was. "Now if the kid went home sick, that's all right. That's excused." She explains, however, that if they are there and they go home without telling the coach, that counts against them. "They get three of those and then we look at whether they're going be in it because our coaches have to come from home. It's no point to come from home if there's nobody there. It's kind of ridiculous."

For her team there does not seem to be a difference between time spent on building events and testing events. It is an hour a week with your mentor for either type. She explains that to have all 23 events covered with two students per event, students need to take 3 to 4 events each. She requires her eighth graders to have four events. "So, that's four hours just in the meeting. And then I expect to take that times four at home. If they want to go to Nationals, they're gonna to eat and sleep and breathe that almost."
"Oh, I've had kids want to do six and I tell them, 'Nope. Absolutely not." Laura says this in response to a question about four events causing student burnout. "I've had some really smart kids take five sessions and they've done it, but they're real tired at the end of the day. I really want them to pick four and put the work in on those." She says it is also a large time requirement for the students to prepare for than many events properly. "If they put an hour in every night in addition to homework, that's a lot of time. But, if you want to go to Nationals, that's what it's gonna take."

When the students meet with the coaches, they are studying old tests that are available, preparing binders, and testing their builds. Invitationals give them a chance to see how they do in a competitive setting. Before regionals, Laura askes the coaches, "Who are your strong ones?" Also, students do not get to go on the invitational trips if they have poor attendance at practice. She says that at the beginning of the year, she will have 60-70 students joining the team (which is basically the entire school), but by the time the invitationals come around about 30 have seriously prepared to compete. She says students may think, "Oh, gee, we get to go to [large city in State A], so we're gonna join Science Olympiad." However, she says that it does not work that way. "We don't take them unless they do the work."

When asked to comment on the suggestion that there is a hyperfocus on competition, she responds, "It's a competition. It is what it is." She says she has had principals from other schools walk by her after her team has won at state and not even congratulate her. She lets her students know that they are expected to clap for everyone else. She says that she has never had a problem when another team beat them to say, "Hey, congratulations! Great job!"

She says that some students take it hard when they do not place at a competition. She explains that she has had instances in the past where everyone on the team has won a medal except for one student. She says she handles these situations by talking with the student and asking them, "Did you do as much as you could do?" She says that if they say they have, then that is okay. "It's not everybody can win. This isn't about winning." Then she will ask them if they have learned something. "That's why we are doing this. We're not doing it for the medals." She admits the medals are great and make the students feel good, but when she sees a student sad and dejected and wanting to quit because they did not win, she tells them, "Well, okay, you can do that, or you could study harder." She says most students decide to dig in and
work harder. She has an example from the current year where she asked a girl, "Well, okay, did you do everything you needed to do ore were you fooling around some of those times when you were meeting?" The girl admitted, "I was fooling around." Laura told her, "There you go. Maybe you need to rethink this, but it's up to you." She says that when students who have been on the team for a year or more suddenly want to quit, she asks them, "What's going on? You know, why are you backing out?" She says some of them will say, "Oh, I really didn't like it." She tells them, "Well, it's too bad. We invested a year in you. This is, you know, too bad. Unless somebody else comes along that's better, you know, you're gonna be in it."

## Advice to Those Coaching Science Olympiad

Laura estimates her competition and equipment costs to start at $\$ 500$ per year. She estimates that if someone were to start a team, they should ask for a minimum of $\$ 1000$ to help cover equipment expenses. She is also assuming that the starting team would have access to a science room with some equipment like microscopes. She refers back to when she was helping with first starting Science Olympiad at her school. "We didn't have a science room that was equipped. A lot of that stuff was donated to us from nurses that worked for doctors that would give us things because they were getting a new model." She tells about how she got four microscopes from the nearby university because she had a connection there and asked if they could have a couple of the old ones they were replacing with new ones. More recently the school got a grant to buy four new microscopes.

Laura's experience supports the idea of start small and some success will bring more success. She thinks the original coach only took students in seven of the events to regionals the first year. "You know, she didn't have a lot, but from then on, I'm telling you we had a lot of kids. We had half the junior high involved."

## Appendix L: Leslie's Science Olympiad Experiences

## Introduction

Leslie teaches physical science for ninth graders and zoology to juniors and seniors and a rural school in State C. She is the only Science Olympiad coach at her public high school for grades 9-12. The school locale is characterized as Rural, distant. National Center for Education Statistics (NCES) data for the year 2019-2020 gave 345 total students and 26.43 teachers with a student to teacher ratio of 13.05. Race/ethnicity numbers report 173 White, non-Hispanic; 116 American Indian, Alaska Native; 36 two or more races; 17 Hispanic; 2 Black, non-Hispanic; and 1 Asian.

## History of Involvement in Science Olympiad

Before coming to her current school, Leslie taught for 15 years at another smaller rural school which did not have a Science Olympiad team. There, she had her students involved in the STEM drone competition sponsored by small university in a nearby city. There was another science teacher with her at that school and they both would take on any competition they knew about. "We were all about getting the kids involved as much as we could, but [we were] on a restricted budget."

When she came to her current school, the principal asked her to take over the existing Science Olympiad team. The coach for the team had left a year earlier and another teacher had filled in but did not want to do it. So, the principal said to her, "Hey, I need a STEM coach. What do you think?" Leslie said, "Okay, I'll give it a go." Of the coaches I interviewed, Leslie is one of two coaches (along with Matt in Appendix N ) with only two years as a Science Olympiad coach. She also coaches at the second to smallest of the schools represented here.

## Perceived Benefits of Science Olympiad Involvement

## Personal benefits.

Leslie teaches in a state where there is no requirement to qualify at a regional tournament to attend state. Any team that wants to compete can participate in the state meet. She says she has not coached a successful team because she views a successful team as a full team that can cover all 23 events and she has not had that yet. "As far as the competitive coach in me, not being able to take a full team to the Science Olympiad event is frustrating." She indicates that their lack of numbers puts them in a situation where they are not able to compete as a team. "We don't enter all the events. So, I just let kids enter what they're interested in." This automatically puts them down point wise in the team competition, so she just tells them, "You're just competing against yourself".

She does think that the individual students are getting something out of it and enjoying it. "And, so, for me, that's why I do it - if they're enjoying it and it's giving them another opportunity they might not have." She says she does not think they are there as a team yet. "But as individuals, I think they are succeeding." So, her gauge for success would be "a true team". She would like a full team that could cover all the events. "I would love to see a larger group that's just completely overtaken with this, and they always have that team they want to beat."

Leslie says she gets a stipend of about $\$ 400$ per year. When asked if she gets to keep it to compensate for the extra time or if she winds up spending it to fund the program, she replies, "Well, I didn't really think of it that way. I just have a tendency to run down to the hardware store and get what they need."

## Perceived student benefits.

Leslie says, "What I really like about Science Olympiad is that often, once students are done competing individually, the administrator of that test will give the kids advice." She says that is her favorite thing. "He's trying to help them get better. I think it helps our kids quite a bit stay hooked up and stay focused on what they're doing."

Leslie says that she sees evidence in content from the testing events show up in the classroom. "You'll see kids reference it in short answer stuff on their test. Sometimes it is from older Science Olympiad events, but not very often. Most of the time it's just from stuff within the events progressing from fall to spring."

Several examples show that peer teaching is an integral part of older or more experienced Olympians leading their fellow participants to success. Leslie says, "I know my son took the fossils test last year and this year he was in a different event." She said her son would check in with the new participant periodically and ask, "Hey! What else do you need to learn?" Or the new participant would ask her son, "What have you seen on the test?" She says that collaboration with peers helps. "Sometimes I'll see my high school kids work their way somehow, magically back down to the Middle School building and they'll be in their STEM room talking to them about the events that they're doing and if they are similar."
"I have 6 or 7 kids that are really dedicated to the competition aspect. The rest just kind of show up because they want to be involved. It's more of a camaraderie thing," says Leslie. "They like to go. They like to hang out and they're with other kids that are like them. That's such a big deal because they'll get together with kids from other schools."

She says that since they are in high school, she lets them pair themselves for the events. "I think by the time they get to that point they know who they're gonna work with the best." She says she only puts pairs together if a student comes to her and says, "I want to do this event, but I don't really have anybody to do it with me." Then she considers who she thinks might be good and asks them if they will give it a try. Sometimes students will come back from the event with, "That's awesome. I'll do it again." Other students find that it is not their "cup of tea" and she is fine with that.

She tries to make sure that there are always two students in each event but there is usually one student who takes the lead in each one. Sometimes at an event someone will get sick and then she must find someone last minute to partner. "I always make someone go with them. Even if they've never done anything with it." She feels that it is important for moral support at a minimum.

Leslie says she know that students are enjoying themselves. "I can just tell with how productive they are." She tells us about how students in one of the build events would build and test their device over and over again. "I mean they were just so excited about it." She says that when the kids are not successful in events, they put effort into learning how to get better for the next competition. She says they will come back and say, "This is what I'm gonna do next time." Due to the distance of her school from all the tournaments, her team does not stay for the awards ceremonies. The build events mostly know what went wrong and needs to be improved during the competition, but the testing events must wait to get their tests returned. There is a several days delay until these results arrive, but she says the students anxiously look forward to seeing their questions. They will look them over and tell her, "Okay, this is what I need to improve." Leslie says, "They're very self-motivated in that way."
"I would say my typical kid is just somebody who's really inquisitive," says Leslie. "Other than that, I'm not sure that there's really a typical kid. I have straight-A student kids and I have the kids that are just barely scraping by." Leslie indicates that in some cases the kids who are just scraping by really find a home in the building events because that gives them a hands-on type of learning experience that is not available in the typical classroom.

Leslie takes all students who are interested in Science Olympiad onto the team. This is different than what happens at the middle school. The middle school selects $15-20$ students to
be on the team. She has a girl who joined in high school because she had not been selected in middle school and it was the first time she could. Leslie says that the girl is doing a testing event and is learning how to research her information, study it, try it out, and re-evaluate it between tournaments.

Most of the students do their work in the one hour after school, but she encourages those who are inclined to continue to work on their preparations at home. She has the example of one student who normally competes in Write Stuff and decided to take on a build event as a second event. Leslie explains that this student will do almost all of his preparatory work at home, and she just has him bring it in before the competition so she can see it. "I don't like to be surprised on the day of the event."

Leslie agrees, "I think more meets would be better. I think the kids would actually be better engaged if they could compete more often." There are not many schools in her part of the state competing in Science Olympiad. She only has one invitational that is somewhat close. That competition does not occur until December, and she says that it is hard to keep the students engaged and focused through September and October. It is hard to motivate them to put work in more than a month ahead of a competition. She says she knows the logistics of it and that her State Director does not have the volunteers to do more invitationals.
"There's so many competitions down in [large city in State C] and it's a long day and we don't do overnight trips," says Leslie. She says it is to the point that the principal who asked her to coach Science Olympiad asked her, "Can't you find competitions around here? Isn't there something closer that the kids can participate in more often?" Leslie wishes she did not feel so isolated. She says, "It would be nice if there was more schools around here involved that we could even collaborate on non-competition days with those other coaches or other teams."

## Workplace and community support.

For community support, Leslie says that she knows of one or two businesses that are pretty supportive. She says that when the students need something she starts recruiting help. She starts asking, "Hey, who can help us with this? Who do you know that has a connection with this business that can help us out?" She said she had a student who went to a hardware store in town and asked the man that cut lumber there how much it would cost if they could take the scrap lumber at the end of the night. The man said, "If it's for a school project, you can just have it."
"Most of the time our support is going to come from the parents," says Leslie. "If we need something and I know that I have several parents that would step up and help. But I don't know financially if they're as supportive and Science Olympiad materials aren't particularly cheap sometimes." She says that her kids are usually rather independent in building their binders for the testing events. "But the build events, I usually like to recruit." Leslie says that most of the time she is needing guidance on how to do some of the builds. She says that is important for the kids involved in the builds to know that they have support. "I guess it doesn't necessarily have to be parental - just another teacher or a motivator or somebody along the way. It's pretty important."

Leslie thinks that expert community coaches that she sees the schools from the larger cities being able to have is amazing. "You'll see some of these mentors coming to the competition and helping the kids, you know, get ready for whatever it is that they're doing. That would be a huge asset." She says that just knowing she could give some events over to others and take a few herself would allow her and the other mentors to really help the kids focus. However, she is at a loss as to how to recruit that from her community. "I just- I don't know those resources that I would need to contact."

Leslie thinks the leading thing that gives a team a competitive advantage is financial support. Though the expert mentor situation would be helpful, she feels that the most important thing to help make the students more competitive is to be able to attend more meets and that comes back to financial support. "I think the kids would be better engaged if they could compete more often." The logistics for her do not work out well. She is about an hour from the closest meet and two or more hours from the other meets in her state. Due to budget constraints, she often cannot attend more than the closest meet and then the State tournament.

Leslie feels rather isolated in her Science Olympiad endeavors. "Yeah. Luckily, I have a really good middle school coach for STEM and Science Olympiad and so I do a lot of stuff with her." She says she does refer her kids out to other teachers that she thinks could help them, but she does not have other teachers coming to the STEM room looking to help. "It's pretty much just me in there." There are two other science teachers at the High School with her. "There is one who is a coach and he's hooked up all the time. I mean, ALL the time." The other one she says she asked for help with Science Olympiad when she first came because she did not know anything about it. "I pretty much got shut down." She thinks he was afraid of getting roped in if he showed up just once to help. "He does help. He's the Physics teacher, so he does help my Right Stuff kid. They have a good connection and I know he'll [the student] go in asking questions in class and so he'll [the physics teacher] help. And he'll let kids come over and work if they need to work on a project as the deadline is looming, but that is about it." When asked about the non-science teachers helping, she says, "Probably, if I ask anybody, it's probably the Ag teacher that we have. He's pretty phenomenal." She says that he will help the students use the 3D printer that they have. Leslie says that she will go and recruit a teacher to help if the kids ask, "But most of the time my kids will just go ask for themselves."

When asked if emotional support from her school and administration was important to her. "Honestly, to me it personally does. It's very helpful to know if I have support or not especially from administration." She explains that the principal who hired her two years ago was the one behind the STEM program, and he is going to Vo-Tech. So, she is concerned about what will happen to the STEM program. She says there are several teachers that will email her and say, "Hey, my kids are done with their math assignment or their English assignment. Are they allowed to come down and work in the STEM room?" She appreciates this. "Even if they're not like helping them in the room, giving them that opportunity to build my program makes me feel like they have confidence in me and what we're trying to do is something worthwhile."

Leslie would like to have more interaction with the other coach from her own school. "Well, you know, when we get to events, that's the only time I really get to meet with the middle school coach as well." She and the middle school coach are at separate school locations. She explains how at tournaments they are assigned separate rooms for their teams. "But we have a tendency to just put both our teams in the same room so that we can meet and discuss what we're doing with our kids and see what might be an advantage." She says that is beneficial, but it is still within her district, and it is not with other Division C coaches. "I know we can go to the coaches' room, but everybody kind of seems like they're trying to make sure their kids are where they need to be like it's the hustle and bustle kind of time." She would like to see the coaches have a separate time to meet because just hearing what other coaches are doing is helpful. As far as the Facebook page in her state, she says that it is used for announcements and event coordination. "I don't see it very often to help me with individual events that we would need more help with."
"There's also some schools that have experts that are volunteering their time and coming in and helping these kids." Leslie sees how multiple coaches could make a difference for her. She explains that it would be both less stressful on her and a benefit to the kids to be able to divide up the coaching work with others. "We could really help the kids focus. That'd be amazing. The expert deal is amazing and, you know. The schools that you see in the top five consistently, they are."
"I try to promote whatever we're doing as much as I can." Leslie talks of her strategy to get the word out about her team. "So, when my kids finish in the top three and we get that email back on Monday, I always make sure that it's in the announcements. We'll try and get pictures for the local paper, but that's pretty much it." The team also enters other STEM competitions and she tries to get publicity for that as well. At the end of the year, she does an award ceremony, and the local paper usually gets that. She thinks that one of the main factors preventing more media coverage in the area is that there are not many schools in her area that do Science Olympiad, so it is not of interest to most people in the area news wise.

## Perceived Challenges of Science Olympiad Involvement

## Personal and coaching challenges.

Leslie cites her drawback as being school size and so many kids being pulled so many different directions. At the middle school they have a class during the day, but when they get to her at the high school, they have difficulty. She quotes comments from even some of the good kids out of middle school saying, "I was just completely overwhelmed in eighth grade. I needed to narrow down my choices of things that I was going to do.'"

For recruiting team members, Leslie has a few strategies. "Well, usually the first thing I will do is find the middle school coach and say, 'Hey, who are your eighth graders that are coming up to be a freshman this year?' and recruit them," says Leslie. She encourages current
team members to bring friends they think might be interested along to meetings. "We have club day once a month where ... I'll have an hour that I can just say to anybody who's interested in Science Olympiad or STEM competitions come to the STEM room." She also benefits from teaching all the freshman so she can recruit them personally in class."The ones I think are pretty studious and they're gonna take it serious, I usually will ask them." With her school situation, not being a middle school participant is not as indicative of high school participation as it possibly is with some other places. This is because at the middle school they limit who can be on the team and their selection criteria is not clear to her. She finds that there are students who were not selected in middle school that are really good in some of the event areas.
"I take them all," says Leslie. So, far she has not had a full team of 15 , but says if she does in the future, she will take the ones that she sees putting in the most effort. "And if I have less than 15 then everybody gets to go. It's just an experience."
"That STEM room was set up for us pretty well, but the materials are starting to run out." Leslie was able to start the program at her school because the school had received a STEM grant from a local business just prior to her being hired. "We don't have the materials that I see some of the bigger schools have, but I would say probably at least the minimum I would get by is with $\$ 500$ a year to keep that going." She also mentions that is could be more because she does not have a really good idea of how much the parents kick in for additional materials that the students use but do not ask for at the school. "Probably closer to a $\$ 1000$ if the kids got everything that they needed for some of those events."

Leslie recognizes that she is at the beginning of this building program and hopes to be able to continue until she has a full team. She talks about how disheartening it is for the students
to see the advantages that the more established teams seem to have. Leslie tries to keep her team focused on that bigger picture but indicates that it is still hard on the more competitive members.

Leslie says that for her as well, she feels the leading factor giving some teams a critical advantage is financial. "I think financial would be the leading one." Beth agrees. "Yeah. Just trying to get the equipment and the things you need. I mean if you can get things into the hands of the kids they just go. So, it's nice."

Leslie does not usually have the problem of what to do with extra students. When she does, she does not take the extras. "I just take the 15. I'd hate for them to go all the way to the city and then not get to do anything all day." Her counterpart at the middle school has a little different situation. "I know she has some substitutes, and she only takes 15 . If you didn't show up on the day you were assigned, you're probably not going back to any more competitions. If somebody got sick, then that's a separate situation."

Leslie says that at the high school level she lets them pair themselves. "I think by the time they get to that point they know who they're going to work with the best." If they come to her and say that they want to do an event, but they do not really have anybody to do that event with, then she will start recruiting a partner for them. "And they'll give it a go and if that was not their cup of tea, then I'll take them another part." She does not like to let a student go to an event alone. "I usually try and make sure there's at least two of them in there. Just like you may need to make sure that there's two sharpened pencils. I mean its more moral support, I think, than anything."

She also lets them choose their events. "I just like to present the different topics to them," says Leslie. "I tell them to go with their passion because then I know they're really vested in it." She says that there are some events that are always more popular than others, but it
usually works out that with so few on her team the ones who are really passionate about that event will still be working on it in December while the others have found a different area more interesting.

Leslie also emphasizes that she is more concerned with just getting a full team to competition and trying to cover all events with at least one strong person than worrying so much about who is better at one event than another. "Sometimes you get to the event, and somebody didn't show up, so you wind up having to mix-match them anyway, but there's usually one lead person for each event."

Leslie sees coach burnout as a problem. She elaborates on her frustrations:

It's so hard to find time to work with these kids and, if you're not seeing their dedication, it's hard for you to stay motivated. Like, I'm not gonna just do this because I get a stipend. Like, I'm doing this because I want the kids to engage and really learn something from it. And, so, that gets a little frustrating. The asking for help and not always getting it is a little bit frustrating. And then last year I went to the - the positive administrator and I said, "Hey listen, there's only so much money left in this account. What do we need to do?" He said, "You might have to start doing some fundraisers so that you can do STEM." And I thought ... like, I already have two other sponsorships that I do. I'm already on the prom committee. I'm already a cheer coach. Like, there's so many things that I'm already doing and so it's hard to think about, "Oh, there's something else that we have to add to the list." When I'm not sure the kids are going to show up, you know. It's... I think they would come and do a fundraiser if I said, "Hey, we're gonna do a carwash and this will get us a Science Olympiad team", they would come. But then to not have- to see the last-minute crank that they do right before an event.

Like, "Oh it's the week before the competition, we really need to buckle down." And you wish they had been doing it for that whole time before. That gets a little hard sometimes - to let them know that the practice isn't just the practice. It's where you're going to succeed in the competition later.

## Perceived student challenges to participation.

Leslie envies the schools that have the hour class for their team to prepare. "It's kind of frustrating because we don't have an hour during the day and by the time they get to be Sophomores really, they're hooked up in about a thousand other activities." Leslie has a small team and has difficulty getting students to commit to regular practice. "Trying to find a time to meet with them gets less and less." She elaborates, "So, I'll see a bunch of freshmen come in from the middle school because they have it as a class at the middle school. And then by the time they're juniors, I'm usually down to about one." She attributed this attrition to several factors. Without the class time in high school, she sees them drift away. She thinks that one of the causes of this is that they get jobs so they can have cars and things. There are also other school activities such as sports. At her school FFA is popular. The students involved in that have a show season in the fall and speech competitions in the spring, so she loses students to conflicts there. To still get in practice during the school day, Leslie says that some students will try to work in a few minutes at the end of class times. "The STEM room is a separate room next to my classroom, so if they had time during the day, they would come down and ask to have the keys to the STEM room."

The first year Leslie did Science Olympiad, she held practices before school. "Getting high school kids up early doesn't always work out real good either." So, she changed to the one hour after school one day a week and if the students need more time, she will stay later with
them. Leslie says that shas a few students who work on things on their own at home, but most of her students are only going to do the scheduled one hour a week and not a lot more.

Leslie uses one student as an example of how if the scheduled one hour a week after school is all the student has, it is not enough. "I have a student in Sound of Music, so he had to build his own instrument. We didn't have that event at the first tournament, so he had another month to build, but at that competition he still wasn't ready." She encouraged him to just take it and let the judge see it and get some more information on it. "I think he would be one of those kids that would really benefit if we had the hour [class time]." She says that he does come to put in additional work if he gets done early with another class. Leslie thinks the build events require more time than the testing events and that students invest a lot more time in the build events than in studying for the tests. She would like to see her students put more time into all events. "I think if they were taking it serious and they were all about the win, they would probably invest a lot more time in the testing events."

Despite the problems with team size preventing them from being strong contenders for overall team placing, the individual students do have a team they always want to beat. Leslie does not name the team, but she says that they always have that one team. "That's their main goal. So, the competitive competitors in us, we want to get them one time."

She sees that competitive nature being a big motivator for some of the students. She mentions that her Boom-a-lever team is very motivated by competition. She has another student who is the lead in the Right Stuff event. "He's very mathematical. He'll come in before the season even begins and show me his plan." She says he always tells her, "I did the math behind it. She says she has other students that do not really put the M in STEM. "They're gonna go out
there and they're gonna build it and they're all trial and error." She implies that they are still very competitive in nature with that approach.

Sometimes Leslie says she see the negative side of competition with a student.

I can see kids that are just gonna go in at gung-ho and I don't know what their expectation is but if they don't finish in the top five, they don't want to go back and do the event again next time.

Typically, she says they come back, but it depends on the student's personality. Her approach that she tells them is:

It's a learning experience and you'll get better every time and, you know, we may never beat some of those bigger schools, but as long as you're improving, it's an asset to our team. You're doing fine.

She says that most of her students have a laid-back personality about the competition. They learn from their mistakes and try to improve each time. Since they do not have a full team, she does not see them worrying about letting the whole team down if they do not do well."They just want to be the one that shines to make sure, you know, that they're doing their best."

## Advice to Those Coaching Science Olympiad

Leslie does not offer any advice for new coaches.

## Appendix M: Mark's Science Olympiad Experiences

## Introduction

Mark teaches at a public middle school for grades 6-8 but coaches the team at the public high school for grades 9-12 in the same town. He assists occasionally at the middle school. The high school is characterized as Town fringe. School data for the years 2019-2020 gave 667 total students and 43.60 teachers with a 14.61 student to teacher ratio. Race/ethnicity numbers report 541 White, non-Hispanic; 56 Hispanic; 29 two or more races; 5 Asian; 4 American Indian, Alaska Native; and 1 Native Hawaiian, Pacific Islander.

School data for the middle school for the year 2019-2020 gave 530 total students and 33 teachers with a student to teacher ratio of 16.06. Race/ethnicity numbers report 471 White, nonHispanic; 31 Hispanic; 19 two or more races; 6 American Indian, Alaska Native; 2 Black, nonHispanic; and 1 Asian student.

## History of Involvement in Science Olympiad

Mark became involved in Science Olympiad about five years ago when some students asked him to coach them. He says that there were a group of high school students who he describes as self-starters that had gone through his science program in middle school and they were interested in having a robotics team and a Science Olympiad team. One of the parents who was an elementary teacher tried to get the teams started, but she felt that it was beyond her capabilities and so helped the students talk Mark into taking it over. "This is just kind of by default and the kids knew they needed somebody, and I was willing to do it and had some skills there ..." He says that he does robotics for the first nine weeks of the year and then switches into Science Olympiad.

Mostly the same students are on both teams. He explains that he has a history of competing with his Science Olympiad students beginning in middle school because there he
takes his middle school students to Technology Student Association competitions. His teams in those competitions have competed at both state and national levels. He has done that for about 14 years. So, it is natural for them to take that experience on into Science Olympiad with him in high school. "They knew the time commitment and they knew what I expected out of them and what they expected for me, and it just worked for the last four or five years. So, we just kind of kept kids going."

His middle school does try to have a Science Olympiad team, but he has not coached it. He says that they have a hard time finding and keeping middle school teachers who will coach it. When they do have a team, Mark helps out a little on the side, but his focus is the high school Science Olympiad team as well as the middle school TSA competition team.

## Perceived Benefits of Science Olympiad Involvement <br> Personal benefits.

Mark says, "Every kid has different levels of success." He says that he personally feels successful where he hears the kids come back from a meet and say, "Yeah, I did this". He also says it is a sign of success for him when the kids come back and tell him, "Thanks". Mark receives a stipend from his school which he says he gets to keep for himself and does not have to spend for the team.

## Perceived student benefits.

"Hey, whatever the kids can give, they give it. That's my philosophy, you know." Mark says he has known coaches that say to the students, "You're either all in or nothing". However, Mark wants to get an many students involved as possible. "I'm a coach. I'm not a dictator." Mark continues, "One biggest thing, I think, is the kids want to do something more on their own and they find an area they like." He gives an example, "I had one girl. There were three different areas she liked and that was it. That was her thing and what she like to do." He says
that Science Olympiad is diverse enough in what it offers that it appeals to a wide range of students. He says he some students that just like to build, some that just enjoying the process of thinking things through, and some that want to do math. "There'd be more kids that would do it if they weren't say involved in sports or have to work." He says that he does have some students on the team that also do sports. "Those are the ones that, you know, do sports and come in once a week and then towards the end they skip two or three practices that week to kind of wrap things up. But that's up to the kids."

Mark comments about the opportunities that Science Olympiad offers for content knowledge beyond what it taught in class. "Good science rooms do that, but often times we're pretty geared towards getting the lesson done. So, you kind of quell the ancillary questions on it, you know." He says he likes it when the students exclaim, "That was cool! Let me go find more out." However, he usually does not feel that he can give them the time to go explore during regular class time. Therefore, Science Olympiad is important in providing some of that opportunity.
"Like in the birds, you know," Mark continues using Ornithology examples, "they're talking about learning the songs and stuff pretty quickly. They're whistling." Whistling bird calls can be important in this event because up to $50 \%$ of the test may be identification of species through pictures, characteristics, or calls. The Ornithology event (short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U) assesses student knowledge about specific species of birds the students study from the Science Olympiad Official Bird List. Students also need to know facts including diet, behavior, range, distribution, anatomy \& physiology, conversation, and interactions with humans as well as other topics (Science Olympiad wiki Ornithology). Mark says that they will ask each other, "Hey, do you know what
this one is?" He says that it is not just Ornithology. "There's Reptiles and Water Quality and they start throwing stuff out. They just kind of open dialogue. That just happens for a couple of hours every night". Even if a student is not into that event, he will hear them throw things out like, "Bet you didn't know this! Bet you didn't know that!" He says that is fun for him and that is what he tries to foster.

Other examples of content that students learn is the students are working with CRSPRs in Chem Lab and learning programming in Detective Building.

Mark says, "Well, they have - kids have to have a goal. They have to have something to work forward or work to and feel like they know something and then they have to be able to share it with other kids."

Mark says, "Oh, some of the kids are just interested in medaling and then, of course, the team part just kind of happens. But the kids are always kind of focused on it." He prefers them to keep the goal of their education and future in mind more. "This last group of kids were more focused on the win, but they knew, they knew their end goal, you know. Get a scholarship and go to college and they matured nicely." He encourages the students to approach Science Olympiad to push them toward a potential career goal. He asks them, "What do you want to be able to do? What do you want to know?"

Mark has the students do the recruiting. "Through the regular science classes the kids kind of pull their own in - other kids of like kind." There is a freshman orientation where students can find out about organizations and activities and the students put up posters. "And then they bring them in and talk them through it and help them out." Mark has the older kids pair up with the younger kids in the events. "You got to get kids and give them the opportunity to do some events, especially, early on." Mark has an open-door policy for his high school team.
"Any kid that wants to we kind of give them, you know, give them a shot at it." He again refers to the current members of the team helping to identify and train newer members. "They kind of bring them on board." He describes how the students will be looking at the events and say something like, "We need something here for this and that kid over there has time and ability." He says he only runs one team and the most he has had was 14 on a team.

When asked what particular factors are really important in giving a team a competitive advantage over others, Mark replies with one word. "Work." He then laughs at the simplicity of his answer but does not feel the need to elaborate. Possibly because he already has. Earlier in the conversation, he discussed the topic of students preparing for competition in terms of hours spent and how it related to student success. This is presented in the challenges section.

Mark says that invitationals are about focusing on events that are weak or need improvement before Regionals. He says that is what they are about. "It's a little bit about team, but more about the event that they need to work the hardest on."

When asked how he knows students are enjoying Science Olympiad, he responds, "Well, 1) they show up frequently; 2) they do things; and then 3) they give you calls and stuff." He uses the Remind app to stay in touch with the team members. He says that if they are on the app and talking and doing things and he asks them questions about how things are going, he can get an idea about how they are doing. Some students are pressed for time and do not spend a lot of time socially with the team, but he asks them if they are learning. If they say they are and they do not express any problem, then he just lets them go on their own. "The proof's in the pudding when they score."

The students need a place that belongs to the team. "Kids like that, that are doing those things, must have a homeroom. They got to have a feeling of a place to belong." Since Mark is
not a teacher at the high school, this place cannot be his classroom, but the high school did provide a space for them to keep their tools and specialty things. "It was just a room that we kind of got assigned to, but it had a nice little storage area to it. I made tool benches and work benches and stuff so the kids could roll things in and out." The students also use the room for robotics and some other things. He says that group of students just said, "That's our room". They go there and work and they're there at night. He says that being able to trust the students is a big thing because there is a delay between the end of school and when he can get there from the middle school.

This room is where the teamwork and camaraderie are evident to him. He says that it is just one big room, and they all get in there and "chit chat back and forth and they try to give each other a hard time". He sees that here is where the leaders of the group reach out to the other students and talk to them. For example, the bird conversation he gave as an earlier example happened in this environment. He says that since he has a small team, he does not have a structured club with officers. He laughs and says that they are a little bit more of a touchy-feely group.

He says that the structure of the organization must fit the needs of the students. He thinks the students feel like they need to be successful at something and this group something they can do. He has seen some students develop leadership skills as part of the team. He gives the example of one student who he had tried to get involved with the middle school competitions. "Super sharp kid, but he is quiet and shy." Mark was not successful in getting the student involved in competition until his sophomore year. "Then he kind of got a little involved his sophomore year and then by his junior and senior year he was a leader of it." Mark says that if
you just spend time with students they develop. "By the senior year that kid you couldn't shut him up, you know. He was a talker and came up with some really cool quips."

## Workplace and community support.

Mark's administration supports him pretty well. He does not have an organizational budget for the team. "If I needed to buy something the administration is really willing to help get it. We didn't spend a lot, though." The school also covered the travel expenses. "They'd give us a van and gas money and all that, I mean, so we never had to worry about anything except for food." He says parents will often buy food for the team at competitions. He also had his team take advantage of opportunities to work concession stands and things so that they could have extra money to buy team t-shirts. "Financially, we didn't have any problems. I had a local company that if we needed any supplies at a hardware store, they would give it to me. No problem."

An important source of support is the parents. Mark asks his parents for support at the beginning of the year and some of them will step forward. "Well, one of the things," says Mark, "they kind of volunteer themselves." He may talk to certain parents but says, "I don't push it real hard." He gives example of some of the help he has received. "There was a parent that acted for a while as an assistant coach. He was a civil engineer with the Air Force, and he would come in once a week and sit with the students to help keep them going. There was also the parent that helped get the teams started. He says, "She didn't have a lot of science expertise. She was just an interested parent that kind of kept it going." There was another parent at that time who also helped get things started. Mark says that parent had helped at another school and wound up taking over the middle school as an assistant for a year.

He describes the last parent to become a strong assistant to him. "This guy has been involved now for 5 or 6 years. So, I kind of trained him." The parent had children in Mark's
middle school STEM program and said, "Hey, I want to hang out with the kids and see what you're doing." The parent followed his children on into the high school Science Olympiad. "After a while when he'd been around enough, he got to know the system enough, we talked enough, you know." Mark explains that the volunteer has gone through the process to be approved for the district and can drive school vehicles which is useful since Mark has other obligations with the school that sometimes conflict. "There is one tournament where he has to take the kids across the state over the weekend for competition because I'm coaching wrestling." He describes his criteria for his volunteers. "You got to vet them a little bit because they have to be able to work out with not just their own kid but work with other kids and they have to know like FERPA." He emphasizes that you must train the volunteers. "If you don't do that, you are asking for trouble. So, they're special - definitely special people."

Mark does not indicate receiving a lot of help from the other teachers at his school. "Oh, a little bit, but not consistently, you know. There are some teachers that would pop in occasionally, just to see how the kids are doing because they were interested in the kids, but not really. No. I try to get the kids to ask for things that they need." There are six science teachers at the high school and six science teachers at the middle school. He says that the kids will sometimes turn to their science teachers for help to set up things. The students do their own research and then bounce ideas off him and the other engineering teacher and then go from there. When it comes to the non-science teachers, he says that over the last ten years or so he has learned who was and who was not helpful. "There's a couple of kids in some of the writing events who had some of the English teachers help on that a little bit. Not much to be honest." Of course, the elementary teacher that was involved in getting it all started helped as previously mentioned but in more of a parent capacity.

Mark has a unique situation on emotional support from his administration. "Oh, well I get a lot of it. My wife is also the High School Principal." This also has a great deal to do with him becoming the Science Olympiad coach. In addition to the students asking him, he says that she said to him, "Yeah, you need to do this because I've got kids and nobody else is doing it, so you can do it."" He laughs. "So, I did. I mean, she knew what my capabilities were. The kids needed something. So, emotionally, that type of support means the administration knew we had some really great kids that needed an outlet."

Mark says he does not communicate much with other coaches in his region or state. "There's a few around the area that I talk to a little bit." He says that if he is going to do an event at a competition, then he might ask one of the coaches that has done that event before for advice on how they ran the event. He says that some of the other coaches have put information on the internet to answer those questions so he will just go there. His state does have a Facebook page and there has been some information on it, but he thinks that the national page is as informative if not more.
"Well, we used to get quite a bit when I first started up," says Mark, "but our local newspaper basically folded on the part with school news - just flat folded. So, there's a year or two in there or actually even this year some where we didn't get the publicity we would like to. He adapted by converting news articles into posts on the school's Facebook page. "And then, of course, any time we had something we always posted it in school announcements, but that's kind of local and that doesn't get out to a lot of the general public like the older folks, you know." He says that his coverage in the paper when it existed was on par with that of the sports teams. "Yeah, for the most part. Yeah, because I usually wrote the story." I ask if he had a bit of a connection there because he was the wrestling coach. "Yep. I just started sending stuff, so,
yeah." For the school paper, he had a different connection. "It didn't hurt that some of kids were on the school paper and would write a few things about it."

Mark says that it is important for the school and the parents to give the team a little bit of support to just do their activity like they would an athletic team. "They gotta have to kind of do it within themselves and establish a culture of stuff. They've got to establish their own culture. Just like any other team."

## Perceived Challenges of Science Olympiad Involvement

## Personal and coaching challenges.

To have a successful team, Mark says you need to begin "with some self-starters and they can go out and recruit some other kids." He says that recruitment is important because you must have a core group that is large enough to compete. He thinks that for a minimum you need eight committed students. Then you need enough staff to monitor and guide those students. "You need multiple teachers to really do it well." In his situation where he is at the middle school, but coaching the high school team, he says it helps to have a staff member in the building. It has been tough for him because he is not in the same building as the students. He says that it is best if the science teacher can be that person in the building. "You need to get some of that stuff in between classes. Just, you know, 10 or 15 minutes here and there on topics is great and I didn't have that with my kids." He says that if students get done with a class early and can come to a room to work on their Science Olympiad for a little bit, it helps. "And I've done enough with kids to know that you've got to keep in touch with them all the time and have some rapport with them to keep them active on it."

Mark says that he does see coach burnout as a problem. "Time. Time. Time," says Mark in response to what factors may lead to burnout. "And then you got to keep kids going. You just continuously have to recruit and then teach kids." Because Mark has been coaching
science competitions for about 14 years, he feels he is quite aware of what students need when it comes to competing. "You've got to push kids. You've got to read kids. And sometimes it's a bit of a grind." Mark's time is stretched, too. As mentioned, he coaches the robotics team for nine weeks. He also coaches the wrestling team for nine weeks that overlap with Science Olympiad.

He thinks Science Olympiad is like most other things in that it comes and goes in cycles. "I've been around long enough to know that teachers teach hard for three or four years and then they kind of ease up and then they do it again for three or four years then they kind of ease up." For him he feels that Science Olympiad coaching follows a similar pattern.

As stated earlier, Mark takes all comers onto his team, but he has had to dismiss a few students over the years. "There's a few that I've had to let go that were emotionally uncontrolled." He says that some students with issues did alright. "If they can't be trusted to work and behave and use the tools and materials properly, then there's a few I had to let go." Mark says you also have to know your students. Some of them work over a period of time and others are great at procrastinating and getting it all done in that last minute, so it is important to help them find the right partner. He says that he tells the students, "I'm your coach, but I'm also your mentor and as a mentor I wear a different hat. I am not going to tell you what to do. I am going to make some suggestions, but it's up to you." When there is a problem in a group or between partners he says to them, "Okay you got a problem? Just tell me what your issues are. I'll listen to both sides and then I make a decision. That's what we do." He thinks being straightforward with the students is best.

As a small school, Mark says that he has a smaller student body to pull from than a larger school. "Just a simple numbers game." Even with that he says his team manages to cover all of
the events where it mattered at regional and state competitions. He said that there were several open events at some of the invitationals, but that was not the focus of the invitational. "They were focusing on certain ones that they wanted to focus on which is what invitationals are about, you know." He says it is not about the team winning the invitational, but about the students and the events they need to work the hardest on before regional.

Mark says that he fits the adage "jack of all trades and master of none". He says that he is definitely not a master of any of the 23 event topics. "I tell the kids that straight up. You got to figure these things out and if we need somebody, we'll go talk to them. We'll go find somebody for you."." He has found it to be the case that a couple of good mentors really helps. When talking about the schools that have mentors for almost every category he says, "Those schools are lucky. They're lucky to get people to do that."

Student personalities are always a challenge for a coach. On the good side is the student previously described who was quiet and shy but emerged a leader. Mark says that some students are quiet and shy like and some are just obnoxious, but you have to work through that. "You know, some kids are - you're happy when they get there and then some you're happy when they leave." What he says the coach must keep in mind is that often the obnoxious student is also a smart student and just needs to be kept directed back toward their task. "You're a smart kid, you know. Your desk is over there." But as stated earlier, he believes that students need goals. He says that once they figure out that they can do something, then they start doing a little bit more on their own. "Then you poke them down the road and say, 'What about this?" Sometimes the student will say something a little unusual. Then he asks, "Well, what do you know about that? How is that interesting for you?" That might become something that they go home and research that night. He says, "It takes time. It takes some questioning. I mean, artful questioning from
some people to challenge a kid into who they become." He finds it is a challenging part of being a teacher to be one step ahead of the students and to "find out where they're headed and ask them some more questions." He says that it is "all those little things they just kind of delve into and they become their own person."

## Perceived student challenges to participation.

Mark talks about teamwork, "They've got to be able to work with a team - work with a partner. I've had some things to work through. Personalities are important." He indicates that some of the students do have trouble working together. "I've had some, especially on the girls, a little more bossy. They didn't quite get along together so much." He says that some of them would procrastinate and the want to get it all done at the last minute and their partners would be like, "No, I can't work that way".

In response to the idea that not doing well in a competition can be stressful on the student and self-doubt or feelings of inadequacy, Mark says, "Sure, there's that. That goes on." To handle it, he gets with the student to evaluate the situation. He asks the student, "What part of the test did you not do well in?" He does not tell the students what he thinks they did. He says, "I try to get the kids to evaluate themselves and then report back a little bit of what they did or didn't do and the how did you fix it?" He thinks this process is important because "it is just a real-life thing, you know," and his role is to guide the students to that. "Sometimes it works and sometimes it doesn't. Sometimes kids get very frustrated, don't do as well and some kids dig their heels in and go."

In discussing competition pressure and if it relates to student burnout, Mark continues, "I'm not going to push them real hard." He says that the desire must be innate in them. "And winnings a lot but winning is more to some kids than others." He says that those who find other things more interesting will start doing those other things and they will be done with Science

Olympiad. The students who see Science Olympiad as contributing to future goals keep working and researching their events. "They eventually get to the point where they feel confident. It becomes them."

When talking about the competition for student's time, Mark says, "I've had a few kids that have had a lot of issues because they kind of thought that they needed to work or had to work," says Mark. "So, that kind of cut into some things and then, of course, the kids out for sports. Those are the ones that, you know, do sports, and come in once a week and then towards the end they skip two or three practices that week to kind of wrap things up. But that's up to the kids." Mark says he does not see a particular loss of students when they become juniors and seniors. "Once they get involved, I probably keep probably 60 to $70 \%$. If they're with me their sophomore year, then they stay on."

Mark says that he does not see a problem with student burnout. He believes that students leave Science Olympiad because they become interested in other things. Some get jobs and that takes their time. As for how much time the students need to spend on competition preparation Mark says that every event is different in how much time it requires. "Some of the builds are incredible. Like the Flight one. That is incredible. The one - Detector Building - way incredible amount of time for the kids to spend on that." Detector Building challenges students to build, code and test a working sensor. The sensor type can change each year. In addition to events being on a rotating schedule, events that are schedule for two or three years in a row may have their requirements or specific focus within the event topic change each year. For 2022 it was a conductivity meter, but prior to that it was a thermometer (Science Olympiad wiki Detector Building). Mark says it also depends on the motivation level of the student, how many events they are doing, and how much time their schedule allows. "I had about three or four kids who
would spend from 4 o'clock to seven o'clock five nights a week." He acknowledges those kids as being extremely motivated. It is more typical for students to spend two hours three or four nights per week from December until the State meet in April.

Mark believes that the build events take more time. With the knowledge events he says that he can just give the students tests periodically and see how they do and then talk about it and decide what additional information the students need to research. The building events require building and testing followed by rebuilding and retesting and that process can continue up until the event. Test files are important for the testing events. To begin with five years ago, they did not have an archive of old tests for the students to study, but now they have about five years' worth. "When we get done with a competition, I'll scan them all in and put them on our Google drive so that we can have those." He says that any new student on the team can come in and access that. "It's probably a little bit more overwhelming for a new kid to come in and say, 'I can't learn all that'." So, he says you kind of have to leave it up to the students on how they want to utilize the archives.

## Advice to Those Coaching Science Olympiad

The cost of starting a team depends on what the school can provide. "It depends upon the events and how much stuff you already have." He explains using chemistry as an example. "If they're really into the chemistry stuff and you need to get more chemistry supplies and the chemistry teacher doesn't really help out, then, yeah, you got to get more stuff." He thinks that equipment and supplies might run a team about $\$ 400$ each year.

Mark says that the cost estimate after travel and entry fees depends on what kind of equipment you need. He estimates $\$ 400$ in consumables. "I might be a little high, but it depends upon the events and how much stuff you already have." He explains that if you have enough safety glasses and equipment, then it depends upon what the kids are wanting. "I mean, you know, if
they're really into the chemistry stuff and you need to get more chemistry supplies and the chemistry teacher doesn't really help out, then you got to get more stuff." He says it also depends on how well they do in the competitions. "Honestly, a lot of the chemistry stuff they don't do much in competitions until they get to Nationals."

There is also a registration fee to register the team to compete each year which allows the team to go to the state tournament if the team qualifies. Each invitational tournament will also have entry fees. Mark thinks that the state registration is about $\$ 90$ dollars per team and then each invitational charges a team fee for entry. He estimates that $\$ 200$ would cover state and invitational fees together and a team might need less depending on how many invitationals they attended. He does not give an estimate for gas and travel expenses.

## Appendix N: Matt's Science Olympiad Experiences

## Introduction

Matt is a biology teacher at large public school in state C. His school district is Pre-K through 12 with a total of 11,979 students. Approximately $11 \%$ of the students are directly certified for free or reduced lunch. High School encompasses grades 9-12 with an enrollment of 3,485 students for the 2020-2021 school year according to the National Center for Education Statistics (NCES). The school's location is classified as "Suburb: large". Matt has been teaching for four years and coaching Science Olympiad for three years.

## History of Involvement in Science Olympiad

When Matt was a new hire at his current school, his classroom was across the hall from the head Science Olympiad coach. He was curious about all the things he saw the students doing who would file into her room after school. He went across, asked a few questions, and found out what Science Olympiad was. "We just kind of hung out and talked science with students." He did that for about a year until the head coach took another job and asked him if he would be the head coach. "I was very, very excited to take over and be the next Science Olympiad head coach." Matt says that he has continued and will continue to coach because he finds the competition compelling. "When I was a young person, I don't remember there being competitions for science and I thought that if I were a student, I would absolutely love something like this." He says he thinks this is a good way to get young people interested in science. Making it a competition means students must set goals and then try to achieve those goals.

## Perceived Benefits of Science Olympiad Involvement <br> Personal benefits.

Matt says he loves seeing students have an "A ha! Phenomenon". He loves seeing students acquire new knowledge and work hard. "My main reward I get is being involved in that
process for young people." He enjoys supporting them and cheering them on. He also enjoys being with young people and seeing them grow and change and develop their full potential. "It's part of the reason I became a teacher." He likes seeing the students gain confidence and achieve their goals. "This makes me feel even better if I had a small part in that." Discussion of how he sees students working hard and setting goals can be found in the next section about student benefits.

He sees his role mostly as a facilitator because he does not order students around and tell them exactly what to do. "I am supporting the [student] president [of the group] and I am reminding them of deadlines and just doing those facilitating things." He tries to model leadership, but he tries to let the president be the leader and influence the team. "That's something else that I very much enjoy seeing is students just take that role and go with it and really become awesome, awesome leaders." He says it is fun seeing the different styles of leadership.

Another thing he enjoys is watching students experiment outside their comfort zone. He says sometimes students try things and confirm that they really do not want to do those things. Other times they are surprised at how well they do at the tournament. He likes to see that expression of pride over something they were not comfortable about at the beginning. Specific examples of this exploration are given in the student experiences sections.

As a teacher Matt feels he benefits by seeing what the students are being asked to do in the different events. He thinks about the event activities in a classroom setting and says "Oh, well, you know, what? I've seen students do this and I've seen students accomplish these goals or solve these problems." He uses this to help gauge what he might introduce into his classroom. "It gives me a better frame of reference for what the capabilities of a student actually are for that
age or for that grade." For example, he says that because he saw that his students competing in Protein Modeling could fold a protein, then he realized that was not an unreasonable expectation for some of his students. "Surely, my AP Biology students can know a little bit about tertiary structure of proteins." He says trying event activities out in his classroom gives him "a better frame of reference to the capabilities of young people."

Science Olympiad also allows Matt to express the competitive side of his nature. He repeats, "I'm a competitive guy" twice during the interview. He says that in the past he has coached volleyball, soccer, track, and cross-country. "So, I have that in me as well - that coaching gene, maybe, is in me somewhere." He thinks Science Olympiad may allow him express that and fulfill that desire and gives that another benefit. "But at the end of the day," he sums up his view of coaching, "it's really just relationships with young people." He likes the personal relationship with the students. "The reward of seeing them succeed is really probably the biggest benefit." When he sees his students succeed, it makes him feel like he contributed something to science. "I'm passionate about science and science education. And, so, this kind of fulfills that kind of goal."

Matt's competitive perspective becomes obvious when asked about his interactions with other teams' coaches. Matt says, "I know of no other coach. I know the teams. I know the names of the teams." He describes a summer event where all the coaches would go and talk about all the different events. The event sponsors would go through their events and explain them. "And, so, we got to kind of pal around a little bit with other coaches, but I don't think that was the - that wasn't the goal of those events. It wasn't to become friends with other head coaches." Matt does not see it as a desirable thing to become friends with the other coaches. "It's like we're competing against these people." He draws a sports analogy, "You're not going
to put like head coaches of football teams together in a room and discuss your strategies on how you're going to win. Probably not going to happen."

Matt was also uncertain about social media platforms for the coaches in his state. "I know that my team has an Instagram so if other teams wanted to follow us, they could, but, uh, as far as I know no other teams follow us. I don't follow any other teams." He comments that upon thinking about that it might not be a bad idea to follow the other teams. "Maybe I should get a head up on the competition. Maybe I should do that."

Coaching Science Olympiad has allowed Matt to feel like he has become more rounded in his scientific knowledge. His background is mostly in Biology and a little Chemistry. The varied topics covered by 23 events exposes him to other fields of science. "The Astronomy events (short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U ) are really cool because I get to hear and see and read what they're doing and that kind of opens me up a little bit to be exposed to a little bit more science." He says it helps give him new examples to use in class. He explains that he pulled Jupiter from Astronomy into Chemistry as an example. The discussion was about gasses and pressure, so he brought up Jupiter as a gas giant that is mostly composed of hydrogen. So, he asked the students if it that meant it was gas all the way down.

And I said, "Well, you know, there's a critical point and there's the triple point and the critical point is when gas and liquid kind of breaks down - like the phase kind of breaks down". And they're like, "Well..." I was like, "Well, yeah, because when you think about gas giants you have extreme situations where you have extreme pressure of hydrogen and so hydrogen becomes like a liquid and then it becomes like metallic. So, it has like these weird properties. Like metallic hydrogen, what's that? Well, it generates a
magnetic field. Wait, what's a magnetic field? Oh, yeah, I know about magnetic fields because of this other, you know, event that I'm learning about.

In this way he pulls the Science Olympiad students into the class discussion and can help them relate their experiences across different areas of science. "I just think it helps me as a teacher to just be a little bit [broader] with my understanding of things." He says his areas of knowledge expansion tend to stay in science. "Probably should do more with like history and like English class."

Matt says he does get a stipend, but only because the previous coach fought for it. He said he would probably do it without a stipend because he just would not think to fight for it like that.

## Perceived student benefits.

Matt sees Science Olympiad as a place where students can develop numerous skills. The first one he talked about is goal setting. "I think having a goal of any type and then working toward pursuing that goal is huge." He believes it is character building and motivating for the student. He ties goal setting and motivation together. "I think it creates a little bit of intrinsic motivation." He defines intrinsic motivation as internalized motivation where achieving the goal is the single reward. He thinks that when a student says, "'I have set a goal and I have achieved that goal.' It's a major thing for a young person to do." He believes this ability to set goals and be motivated to achieve them is very important. "It's a life skill that really would propel anybody to accomplish just about anything."

He talks about things he calls "soft skills". He lists items such as learning to make eye contact, talking with complete sentences, being adaptable, being able to problem-solve, being a teammate, and being a leader. "These are all good skills that I think kind of complete the
education process for a young person." He states that it is hard to teach these skills, but he sees Science Olympiad providing a setting conducive to students learning them.

In addressing the specific skills that a student would learn in Science Olympiad that crossover into the traditional classroom, Matt mentions that the students learn skills involved with problem solving and how to take tests to be competitive in Science Olympiad. This helps them do these same types of tasks in a classroom setting. Additionally, learning that they need to seek out experts for help and talking with the coach and event leaders makes them more comfortable in talking with adults and teachers outside of Science Olympiad. Matt gives an example of a student who had trouble communicating. "They are interpersonal, so they had trouble expressing how they felt. They had trouble communicating in a comfortable way with individuals." The student came back to visit him, and he noted that the student had really blossomed. "I can't scientifically identify and say that it's because of Science Olympiad...but I'm sure it has probably a small factor in their ability to communicate and talk to people and express how they feel in a very comfortable way." Research skills are another thing that can help them on papers in classes outside of science as well as prepare them for college.

The single skill he spends the most time talking about and keeps returning to is leadership. He has his team organized with several leadership roles for which students can apply. He names president, vice president, treasurer, and project manager for these roles. He has developed a process like a college or job application where students must explain why they would be good in that role and procure three letters of recommendation. "There are definitely leadership opportunities and there is definitely modeling of leadership going on in Science Olympiad from a lot of different angles not just me." He personally thinks the project manager is the most important role. This is a role he has created, and it seems unique to his team. The
project manager is the student who communicates with each participant and decides which events everyone is participating in. Matt likes the project manager approach better than the more common practice of the coach keeping a spreadsheet of attributes and likes for each student. Other coaches in this study use the spreadsheet approach to match students' interests and abilities to events. This approach will be discussed further in those cases. Matt says, "I just leave it up to the project manager because they have a better feel and understanding because they're in the mix of all those different school events that are occurring and they're friends with all these people too." He implies that the students make better team pairings and event assignments than he would. He keeps an oversight and if he sees anything he thinks is going unnoticed or needs to be addressed, he talks to his project manager about it. "If you treat a student like a leader and if you treat them like an adult, they'll start acting like an adult and act like a leader."

There are some other benefits that Matt sees to Science Olympiad participation beyond skill building. "I've had students who have gone into the medical field very likely because of Science Olympiad." He cites the Protein Modeling event for sparking their interest. In this event participants are expected to pre-build a model of a protein and bring it to the tournament. During the competition the students manipulate protein structures using the provided online protein visualization program and demonstrate an understanding of basic features of protein structure through a written exam. Matt also gives an example of the opposite happening where a student lost interest in an area. One student was planning to go into the medical field, but because of the Sounds of Music event they decided to continue with their interest in music and the science behind it for a career instead of medicine. In the Sounds of Music event the team of two builds an instrument on which they can play a scale. The team then demonstrates their knowledge about the physics of sound by answering questions on a written test (Science

Olympiad wiki Sounds of Music). "So, definitely Science Olympiad can be the vehicle to lead a student to a pathway or a career where they can find real enrichment out of that."

Matt feels that the team experience is another important benefit of Science Olympiad participation. Even though he says he does not really see a typical student type for Science Olympiad, he does say that most of his Science Olympiad students are very academic and not typically the athlete. "It's nice to have a non-athlete actually be able to compete like an athlete would in an academic style situation." He then points out that he does have athletes on the Science Olympiad team by giving the examples of the team president who is a black belt in taekwondo, another team member who runs track, and a third who plays volleyball. So, every student is unique, and everybody brings their own expertise to the table. In general, though, Matt likes the opportunity Science Olympiad provides students who would not otherwise get a team experience. "They get to experience [in] team play, and they get to experience winning and losing and camaraderie and all these other things that you learn in an academic setting."

Because of the team aspect Matt sees students working together that would not normally be together in a classroom setting. With a large student body of over 3,000 in the school, even those students with similar interests might not be in classes together. Also, mentoring of younger students by older students and pairing a more experienced person with a newer person on a team for an event means that students who might not otherwise know each other are working together. "When you have a common goal and you work together for weeks and weeks and weeks and months on end throughout the entire year, you develop a kinship."

Of course, there would not be a need for a team without the competition. Matt has already discussed how he enjoys the competition personally and how important he feels goal setting is for students. Achieving those goals of doing well in a competition is hard work. As
just mentioned, this hard work can bring students together into friendships. Matt also sees it providing an opportunity for parents and students to work together. Parents can volunteer to mentor students in an area of expertise or interest, and they often choose to mentor their child's event. Matt compares it to Dads coaching their children in sports. "I enjoy coaching my son in flag football because I like being with my son," he explains. Science Olympiad gives a somewhat unique non-sport venue for a parent-child bonding. "It's a very interesting opportunity with Science Olympiad to have a parent be involved, but also have a relationship with their own child in something they are passionate about."

The focal point of all this hard work comes on competition days. Students are often surprised at how well they do when they did not expect it. There is a realization that things are not just hard for them alone. He hears comments like, "Oh wow, other students are also dealing with the same troubles and issues that I have?" Placing higher than expected is obviously fun and winning recognition is vindication of the work and time the student put into preparation. The awards assemblies pre-Covid were exiting for the students. Matt describes them as a "Price is Right" type experience where each student is called down to receive their medal. "That's really cool because their teams are cheering and everyone's looking around like, 'How many did they get?'" The students are all trying to add up the points in their heads to predict what team is going to win ahead of the announcement. The anticipation is a lot of the fun. "They do enjoy that."

Even when a student has not succeeded, there is still a lot of fun happening. Matt uses the Wright Stuff event to give an example of how a student can spend a lot of time and effort building a plane only to have it go down after two seconds in the air. This event is a C division event where participants make, test, and fly an airplane powered by a twisted rubber band. The
goal is to have the airplane with the longest flight time. (Science Olympiad wiki Wright Stuff). He says they are never down or feeling worthless about that. They laugh. He hears them say things like, "Ah hahaha. That's so funny. Oh, I can't believe that happened." Matt says, "Even if you mess up, it's still fun, which is OK."

The whole day of competition is conducive to the team having fun together. Each team is assigned a room that is their homebase. They order food and eat together. Different events are scheduled at different times, so students who don't have an event at that time will go to the build events that are open to spectators and cheer on their teammates. "It's just a fun day to kind of spend doing some science."

## Workplace and community support.

Matt does feel that he has support from his school. He gets a stipend as well as a budget which is sustained with membership dues and fundraisers. The budget is not large enough to handle travel expenses, but his principal has said that if they were staying in state, the school would provide a bus and a driver. He classifies that as a type of facilities support. His first year as coach he hosted an invitational and so had use of the school to set up all the events. Some of the other clubs also had students volunteer to come and help. Volunteers are needed at an invitational in several capacities. Each coach bringing a team is usually expected to supervise one event. However, that typically does not cover all the event categories. Therefore, other teachers in the school and community members are asked to volunteer as well. Noncompeting student volunteers are assigned to assist the event supervisors with set up of the event, paperwork, keeping scores, and running timers for the timed events. Student volunteers may also run the check-in table and act as guides for helping teams find their rooms. Unfortunately, Matt has not been able to host another invitational due to the pandemic.

He reported that he did not get the expected help from his colleagues when working on his first invitational. He says he may have been a little naïve to think that others would be willing to give up their Saturdays to help students in this fashion. "I've asked a lot of people to help me like sponsor an event or do this or the other and they kind of fell through and so I had to ask like my own personal friends." He says next time he will plan a little better. "I'll maybe have some gift cards, or I'll have something from our budget that helps entice some people to come in on a Saturday." He only has the one invitational experience, so he does not know what the best approach might be to entice people to volunteer.

The other science and math teachers do respond to questions about Science Olympiad event problems from students during the school day. Matt encourages the students to go seek out these experts when they need help. "The high-level math teacher is literally next door and so he teaches Calculus 3, linear algebra, differential equations so those are like high level math that I am oblivious to - so I know he is cool with students asking questions." Matt states that if a student is earnestly wanting to know something most teachers will never turn them away. He thinks some of the teachers probably enjoy it. He gives an example. "The high-level math and AP Physics teacher has definitely gotten a little kind of geeked out a little bit on some of the questions that students have brought."

Pre-Covid, Matt says the parent support was massive. However, with Covid, only students were allowed on campus. "Parents aren't going to dial in to like a bunch of kids screaming at each other on a virtual call ... a teacher doesn't even want to do that." Traditionally, prior to Covid, a parent of the president acted as a lead parent to communicate with other parents about food at meetings or tournaments, getting things the team needed, and coordinating transportation. There has only been one other parent that he observed helping the
students and that was under the previous head coach. The parent was an engineer and enjoyed helping with the builds. Possibly because he was mostly observing and not occupied in coaching the other students, Matt noted a drawback to parent coaching. "Some people have not been trained to be a teacher. I probably would have let the student fail a little bit more in trial and error." He says that even when you see students doing it wrong, you need to let them go ahead and do it. If he had been the coach when he noticed that he would have pulled that parent aside and said, "I know you know what will happen if they put things together this way, but let's let them discover that."

The team does not experience student support from non-participants in the form of pep assemblies or some way of cheering them off to a tournament. "That would be awesome. I don't see that happening at our school." He says they do get recognition in morning announcements, and it also goes out in the online publication to every student. He says articles about them get some "likes" so he hopes that drums up a little more interest from students.

Matt says he enjoys the support from the state Science Olympiad organization where they hold a summer workshop, and the state director would talk about all of the events. The event sponsors would also go through their event and discuss their expectations.

## Perceived Challenges of Science Olympiad Involvement

Personal challenges.
Matt says his biggest personal drawback is time. "It's after school two days a week and then on a Saturday and sometimes on Friday if they haven't finished building their stuff." Some of the events require students to build models or machines before the competition and these can require a large amount of time from both the student and the mentor. He points out this takes time away from his family. Another drawback he mentions is trying to make purchases and pay tournament fees in a large school. "You got to get your receipt here and you got to take your
thing over there and you got to do this over here and so it's just very -uh- the protocols, uh, is annoying." Matt says there are just so many steps to go through because they are a club and have a budget. "Why can't I just like, you know, do something and you pay me back kind of thing." For him it adds to the work of an event. "It kind of takes away from the fun of just 'Hey, let's just do some science'."

## Perceived student challenges to participation.

Students mainly have the same major issue of time in Matt's opinion. "They're usually in high level academic classes which requires time outside of class to read and study and all that kind of stuff." He says that they may want to spend hours and hours building or studying for their event, but they have so many other priorities. They are also active in other school activities. He uses his treasurer as an example of a student who is also an officer in another school club. He sees the drawback being more than just the student not being able to spend the time they want to on Science Olympiad. "They might feel like they're letting the team down if they're not all in all the time spending hours and hours." He says they are really pushed and pulled in every direction.

## Advice to Those Coaching Science Olympiad

Matt has only been doing this for two years, so he is still learning what works for him. Having the majority of those two years coincide with COVID also means that the theater of operation may have required practices anomalous to what will work in the future. The one piece of advice that Matt gives to coaches is to create the project manager officer position on their team. As previously described, he feels the project manager is more in touch with that the other students are doing and can make better decisions in pairings. This also gives a student an opportunity to learn valuable organizational and management skills as well as keeping the team student led which reduces stress on the coach and gives students valuable leadership experience.

## Appendix O: Robert's Science Olympiad Experiences

## Introduction

Robert is a Geometry and AP Physics C teacher at a private school in State C. His school is a Pre-K through 12 with a total of 952 students in the 2019-2020 (most recent available) NCES report. Its location is classified as "large suburb". No income demographics were available through NCES or the school website. He is a retired licensed Professional Engineer (Mechanical) who has been teaching high school for 12 years and coaching Science Olympiad for five years with three of those years as head coach.

## History of Involvement in Science Olympiad

Robert says that he "retired to teaching". In his previous career as an engineer, he did a lot of professional instruction both while in the Navy and later when he worked at a commercial nuclear power plant. "I've always enjoyed teaching and so being a teacher just came natural." Robert has a background that gives him a wide range of experiences for teaching. When asked what field of engineering, he replies, "Well, mechanical by education, nuclear by training, and electrical by practice." He spent most of his career doing the development, design, construction, start-up and operation \& maintenance of power plants. "I was the general manager for [large petroleum company's] co-generation development for all of North America, I had my own consulting practice, and I was the co-founder and President/Chief Operating Officer for a renewable energy company developing projects in North America, Central America, the Caribbean, and Europe." Robert says he was doing all this, and his wife said, "You know what you do is either on the road or on the computer. We can do that from [city in State C] where the grandsons are." So, he resigned from all his positions and moved. Where he had lived previously, he had been a substitute teacher while running his consulting business. He says he
had to block out time for his business or schools would call him. "But I could teach anything that I was subbing in and that was different, and I enjoyed that."

After moving to State C , his daughter-in-law commented that the state really needed teachers. He said, "Well, I enjoy teaching, so I guess I can go get certified." He now has six teaching certificates including biological sciences, chemistry, physics, mid-level math for High School credit, intermediate math, and advanced math. Robert mildly jokes about how he started coaching Science Olympiad. "Well, they faked me out and made me agree to that [coaching Science Olympiad] right at the beginning and before I even knew what I was getting into." It is called the plus one at his school. "You know, the other activities that teachers do to support the school and I thought it sounded cool." At his previous school, Robert coached robotics, but says he did not realize how much more work Science Olympiad would be. "Well, robotics is very intense for about two months. Science Olympiad is not quite as intense, but it's a lot longer because it's literally all year." At his current school, he started as an assistant coach for his first two years and became head coach for these past two years.

## Perceived Benefits of Science Olympiad Involvement

## Personal benefits.

There is not a single statement answer to explain why Robert has stayed involved in coaching Science Olympiad. On the surface his comments sound like he is doing it because his job requires it. So, I asked him bluntly if he would be doing it if it were not part of his job?
"No," he replies after a deep sigh and time to think. "Yes and no." He continues to explain that from a love of teaching he would like to coach Science Olympiad, but on a practical basis as a teacher it takes up a large amount of his time. He relates how his wife is not pleased with the large personal time cost. It does not take long to come out in the conversation that what really keeps his interest as an engineer are the builds. He has a passion for teaching beyond
academic knowledge. "The process of learning how things work is something that I think our education system is way behind." He wants to see kids learn to physically build things so that they must work through problems.

He describes how the students generally have little to no knowledge of tools. Something as simple as the differences between two screwdrivers is unknown to them, so power tool use is totally foreign. These skills are necessary for students who are competing in the building events.

All these subtle little things that I learned because my father was an engineer and I'm an engineer and I built a lot of stuff when I was younger and just that was what I grew up with. And these kids they don't know how to hold a hammer and they don't know the different type wrenches or what they are for.

Robert is frustrated and concerned about this lack of practical knowledge he sees in his students. "Kids don't learn it at home anymore, so they don't get the practice. They don't understand the subtlety of what's the best tool to use." He describes how he teaches them to safely use different types of saws and why there are different types of bits to use on a drill for different purposes. "They don't even know the terminology let alone how to pick the size and length and the pieces that go together to make what they want to make." He feels these are all important life skills. "I enjoy teaching kids how to do that so that then they can feel proud when you can turn them loose and they can pick the right size bit."

Robert says that he has developed relationships with students over the years. His first year at this school he helped a lot with the middle school team because they were doing builds and that was what interested him. There are students in the high school now that remember him from five years ago. "Because of my Navy background and that military discipline and everything, a lot of the freshman coming in are afraid of me to start with." He does not want to
diminish that because it helps with class control, but the Science Olympiad students he worked with in middle school understand that he is strict but helpful, so they come in with an understanding that helps to establish a working classroom relationship.

He says that the social interaction with the students in Science Olympiad helps in the classroom. He notices that if he has taught a student as a freshman or sophomore and then has them again as a junior or senior, the students feel like they have that relationship with him. "It's even stronger with the ones that participate in Science Olympiad." He says that those students are not quite as afraid of him, and it helps. "If you have a two-way conversation with the students, it really facilitates the learning in the discussions and things like that so they're not afraid to ask questions."

Another personal benefit Robert mentions is being able to work with some good assistant coaches this past year. The coaches have social interaction on a periodic basis when they get together to solve problems, figure how to allocate resources and schedule team workdays between all of the conflicts they have to manage. He says that it is enjoyable to interact with them and share with them the administrative tasks it takes to run a team. He likes "bouncing things off and sharing our perceptions of different students and coming to appreciate some of the hidden skills and hidden talents that we discover in some of the students."

This is the first year that Robert has received a stipend. "I'm the only one in the upper division that I know of that's getting it and not to put too fine a point on it, but it's minimal." He says he gets $\$ 2000$ for the whole year which is the same as a part-time assistant sports coach gets for a cumulative 200-hour season once a year. "I easily put in 200 hours a month, every month." Science Olympiad is not a seasonal activity. It runs the full school year. So, this topic will be addressed further under the challenges section.

## Perceived student benefits.

Robert is passionate in his view that education should go beyond a focus just on academic concepts. He sees Science Olympiad being of greatest benefit to students because application of knowledge is a part of every event. He gets personal satisfaction out of seeing students learn how to apply knowledge. He describes pure academic knowledge as a good base. "But unless you know how to apply it and you know how to problem solve with it, it's kind of a wasted skill." He explains how he sees a dichotomy between the curriculum list of topics and the Science Olympiad events. "It's a huge spectrum of exposure to science that obviously when you take biology, chemistry, physics and then maybe anatomy in a curriculum, well that's four topics." Science Olympiad goes beyond these four subject areas to comprise the twenty-three events each year. Many of the events change or rotate on a regular basis so that a student who is in all four years have more than twenty-three options to explore over the course of that time. "There's a lot more just introduction, if nothing else, to these different fields and concepts."

Then he mentions the depth of knowledge that students must develop to prepare themselves for competition. He gives the example of Biology. He says there is a "very shallow, but broad scope of topics that you cover in a biology class." He compares that to some of the biology events where students develop a thorough understanding of a particular problem that is presented in the event. An example from this event is that students had to look at a particular type of pollution accumulating in a specific waterway that was affecting an amphibian population. Robert sees this as more associated with the real world than what is frequently covered in the classroom. He points out that the reason the classroom must be more generic in coverage is because it has to provide a broad base for students who will go into diverse specialties. "I don't think there is a school that could afford to have a class on every one of the different science events that we participate in."

Even outside his favorite hands-on builds events where it is more obvious, he sees the ability to apply knowledge and the skill of problem-solving as crucial for students to be successful competing in their events. "They have to kind of go outside of sort of the standard program that you get in a curriculum and think a little bit farther." For example, he says it is not just about knowing environmental chemistry; it is about applying it. "What happens when you acidify a lake from acid rain?" The event he is referring to is Water Quality. In this event students apply ecological principles to a situation in a particular aquatic ecosystem which may change from year to year. Students will also perform some water quality tests related to the problem (https://scioly.org/wiki/index.php/Water_Quality). For short descriptions of all Division B events see Appendix T and Appendix U for Division C events. He says that topic might get three minutes in a classroom lecture. "Here they're doing problems where they're evaluating what's the impact of that situation (i.e. acidification of the lake)." He thinks this is important to expand the students' understanding of the world and for them to see how the academic knowledge is useful. Referring to a previous quote, he thinks it is important for students to learn how to apply scientific knowledge and skills.

Robert runs his team with three co-captains. Two of these students are additionally designated as the team secretaries. "They keep the administrative records, and they take attendance lists and things like that and keep track of that." The team captains are all seniors. Part of the responsibility of the captains is to motivate and to lead the other members of the team to participate and be on time. Robert says that is not something the coaches should be dictating. "We need the students to feel emotionally responsible for the team and to make things happen." When the team travels to in-person tournaments, the seniors are each assigned to be responsible for groups of students. "It's an important life skill for them to learn how to do that."

The seniors are also in charge each year of designing the shirt that both the middle school and high school team members wear. Robert says that last year their shirt design was in contention at the national tournament for the honor of best design. "We didn't win but it's kind of cool that there was this voting going on for our design."

Before Covid-19, Robert's school competed in 8-10 invitationals each year and would travel as far as two states away for some of them. "By competing in these invitationals in other states, we're getting a broader, more competitive environment to teach our kids just how hard you have to work in order to win one of these things." This year they were only able to find three invitationals and only one was in person. They won two of them. Robert says that in those two wins they were able to demonstrate to the students that the win did not come because they had a superstar in one event. "We had decent performance in every event, and it was because we did every single event and had a decent performance that it's the cumulative score of everybody participating is why we won." He emphasizes that the teams that came in second place did better than them in a number of events, but they did not participate in all the events. That was one of the decisions the team made at the beginning of the year because it was something Robert learned from the previous coaches. "If you just show up and you do something, you may not be world class in it, but [you are] getting three- or four-point placement instead of a 15 nonparticipant points." He says that made the difference between them and the second-place team. He says he thinks it is important that the students understand it is a team effort. "That's why we win."

Robert says that the invitational tournaments are important for the team to develop camaraderie and have fun together. He says that doing things together like traveling, being on the bus for six hours, being in the hotel, and going out to dinner are all team socializing activities
that the students look forward to and consider fun. He does not state that he sees new friendships forming but sees it as an opportunity for friends to hang out together at an activity outside of school. "They're with their friends quite honestly because, you know, all the smart kids hang out together." He says at the tournaments the teammates run around to all the different events together. When they go to nationals, they try to arrive a day early so they can walk around and explore the hosting campus. It is also a tradition to take an extra day to come home. Robert says, "I found out the history, you know, they've been so many times to the national tournament, they always plan to spend that extra day sort of as a reward for the kids that hung in there to go explore these awesome tourist places wherever the national tournament was." He says that the year he went, they took the students to Niagara Falls. "It's a social activity for this travel and I think that helps solidify the ownership of the team."

At tournaments, Robert says that they get pumped up about doing well and cheering at the awards ceremony for the team and the individuals that medal in their events. The camaraderie and sense of team spirit was evident to him even at the invitational they did not win this year. "Just the fact that they could cheer for individual team members that medaled was kind of cool and so we have that camaraderie within the team."

Robert says that it is difficult to say if Science Olympiad helps test scores or classroom scores because the students on the team are the smartest kids that are highly motivated. "It's kind of hard to distinguish whether they got those good scores because they're just super smart kids or because they spent the last six years in Science Olympiad." He says that he also cannot say there is a discernible relationship between competing in specific events and doing well in specific related class subjects because they are all the smarter students who do well anyway.

Having only been a coach for five years, Robert says that he does not have enough data to state whether Science Olympiad participation affects career choice. He thinks it is likely that Science Olympiad participation sparked interest in some students for areas and because they enjoyed it, they pursued it in college. He knows of one student that excelled in some of the build projects that is now majoring in engineering. "I don't know that this necessarily was the only reason why he chose that as a major because he had a natural talent that was just unbelievable, but it probably helped reinforce his enjoyment in pursuing that type of STEM career."

As mentioned in the Coach Benefits section, Science Olympiad gives an opportunity for a better student/teacher relationship. This also is a benefit to the students because they know they have that resource. Robert says, "Basically, any kid that I'm teaching now, any kid that I've taught in the past or any kid that just has a question, they can - anytime that I'm not actively teaching - I make myself available to help and because I'm certified in all the math and sciences, they come to me for everything." So, even if he is not their teacher for that subject, the students who know him and they have a good relationship with him come to him for help.

## Workplace and community support.

The history of Science Olympiad at Robert's school is interesting. For years there was only a middle school team because the upper division science chair felt the students were already overloaded and therefore would not support the activity. It took a middle school history teacher whose son had been on the middle school team becoming a high school teacher and being adamant that there was going to be a team. So, for years the Science Olympiad coach was a history teacher. Then Robert was hired, and he and another math teacher were assistant coaches. So, it took years for the school to have a member of the Science Department be a coach. When Robert moved to teaching Physics, he was technically in both departments, so that started a change in this. He says that science faculty are willing to help answer questions, but they have
other time commitments that make them not want to or be able to be involved in Science Olympiad. This year, however, the is one math teacher and the Science Department Chair are both serving as assistant coaches.

Robert does have parent support. There is an MD and a PhD who each help with the Anatomy and Cell Biology events each year. The PhD parent helps coach the Cell Biology event. This is a lab-oriented event where students answer questions, solve problems, and analyze data about different types of microbes (Science Olympiad wiki Cell Biology). This parent was introduced to the [state C] director and he got sucked into being an event supervisor for Cell Biology for a couple of tournaments and now he's going to be the event supervisor even for the state tournament." This parent comes when the team has workdays and spends about an hour and a half giving a lecture and answering questions about the scope of what the event will cover. "And the fact that he's an event supervisor now kind of helps guide the types of lecture content that he has."

The MD parent is an orthopedic surgeon who comes and lectures the students on Anatomy. In that event the students will be assessed on their understanding of human anatomy and physiology for the systems (ex. respiratory) chosen for each year (Science Olympiad wiki Anatomy and Physiology). He has been helping the team out for several years. His daughter started out on the middle school team and is now a senior and one of the captains on the high school team. "He's just one of those super nice guys that volunteers his time to help our students."

One of the coaches has a spouse who works for the National Weather Service and helps with the Remote Sensing event because that was the focus of her PhD. In the Remote Sensing event, participants complete tasks related to climate change processes in the Earth system by
using remote sensing imagery, data, and computational process skills (Science Olympiad wiki Remote Sensing). This volunteer has also traveled with the team the past two years to a tournament a state and a half away in Anne's city (Appendix G) to be the event supervisor for Remote Sensing. This is important since teams are asked to supply one or more event supervisors when they attend an invitational to help make the competition possible.

Prior to Covid-19, there was a set of parents who supported their daughter through middles school and high school competitions. "We did a lot of away tournaments when I first started, and they traveled to every tournament and were helpful to go run and get lunch for the team type of thing." He says he does not have any community volunteers that are not parents.

The only publicity Robert gets is when he forces his way into the school announcements. "We don't get 'Rah, rah' support from the school." He says he tells them, "Hey, we won." The response he gets is, "Great! When's the game?" Occasionally, they'll get a blurb in school communications to parents saying they won a Science Olympiad tournament.

Robert discusses how the coaches support each other by dividing the events between them. He says that this year there were two build events that he did not get to help because he was busy doing other aspects of Science Olympiad. One was a wi-fi receiver for the event, Wifi Lab. For this event teams construct an antenna device designed to transmit a signal at 2.4 GHz before the day of the competition. At the competition the device is tested, and the students complete a written test on the principles of electromagnetic wave propagation (Science Olympiad wiki WiFi Lab). The second event is called Detector Building. This event challenges students to build, code and test a working sensor. The sensor type can change each year. For 2022 it was a conductivity meter, but prior to that it was a thermometer (Science Olympiad wiki Detector Building). He says he was fortunate that another coach was able to pick up those two
events as well as managing which students are doing each event. "I don't have enough time to do every single build and so fortunately he's got the talent to pick up some of those more electronic ones." He says that it is good to be able to share some of the administrative activities that it takes to run the team.

Robert says that when he first learned he would be head coach he tried to recruit some of the science faculty. He explains that one is a wrestling coach. "It's hard to get them to commit to the time because they don't want to spend weekends here when they're already spending 60 hours a week." He says they are willing to answer questions when students go to them during study hall or when they have a planning period, but it is difficult to get them to commit to direct support.

The middle school has a maker space that the upper division students are welcome to use, but they must go to the middle school to do so. Some of the tools are available for use anytime a student needs them. Others, such as the power tools, require the students to go through training before they are cleared to use them. Some of these power tools include circular saws, radial arm saws, miter saws, and a drill press. There is also a band saw that only teachers are allowed to use. He says they do not have a full-sized table saw, but they make do with what they have. The high school drama department has a full-size shop with a table saw as well as some other big tools and equipment. He says it is for the set design class. "I haven't had a need to push our way into that." He says most of the projects they are doing for Science Olympiad are small.

One of the middle school coaches oversees the maker space. The students get to rotate through a maker space class. "It's not specifically dedicated to Science Olympiad, but there are a lot of skills taught there that are applicable to Science Olympiad." Robert says that the middle school has a lot of advantages that the high school does not have. Robert says that he has been
able to help them, too. "Specifically, because of my engineering background, I can help solve certain technical problems as they do their build projects." He says the middle school used the technology the high school developed for the Ping Pong Parachute event because it was simple, and it worked. In the Ping Pong Parachute event teams bring to the tournament bottle rockets they have designed and built to launch a ping pong ball with a parachute attached. The goal is the keep the parachute aloft for the greatest amount of time. (Science Olympiad wiki Ping Pong Parachute)

Robert does have a budget for Science Olympiad. However, it is one budget for both middle school and high school teams.

He says that he and the other coaches had a formal meeting with one of the school curriculum managers about having an elective class for Science Olympiad. He says they received a favorable response in the beginning, but the final response was, "No". He says there is a lot of talk about supporting STEM, but he does not see a true understanding of what that really means. Robert's views on this will be further explored under the Personal and Coaching Challenges section.

## Perceived Challenges of Science Olympiad Involvement

## Personal challenges.

The personal drawbacks Robert repeatedly mentions is the amount of time it takes. The team tries to practice two or three Saturdays before individual tournaments and will do several workdays during the Christmas holidays. "That gets really tough trying to, you know, commit that time for the coaches, too. I can tell you my wife is acutely aware of how much time a teacher spends at school that's personal time." He suggests that an hour elective class for Science Olympiad would benefit both him and the students in reducing the time cost. "There's a
definite personal cost to the time especially because we don't have a class time that would not minimize but mitigate some of the demand on weekend time."

Robert has already talked about his efforts to recruit more assistant coaches. "There are teams that we go up against that it's integrated into their curriculum. They have amazing resources. 23 events they have 23 coaches, so they all specialize. That's amazing." He says he has a challenge just getting a handful of coaches. He blames this somewhat on the number of other demands that are placed on teachers. "You know, between also being coaches and being chaperones for the dances and doing STUCO stuff and clubs." Again, he discusses how Science Olympiad is an activity that goes on all year whereas the sports are only about a third of the year each. "It never stops and that's a huge time factor requirement and hard to get people to sign up for that."

Robert says that it is easy for a coach or even a group of coaches to get spread too thin because there are so many different events. Having four coaches this past year is the most the team has ever had, but they struggle to efficiently manage their time between all the events. He says that he assists as much as he can with the other events. "Manpower efficiency wise I'm better putting my time into the build events and letting the other teachers handle, you know, some of the other events." He says physically he even has trouble covering everything he wants to do for the build events. "Because of my engineering background that's the most efficient use of my time to help them."

He says that one of the hardest parts of coaching the builds is to get the students to read the instructions. "It's frustrating, but it's important, I think, that they get that hands-on type of instruction." Following instructions to build something and being willing to try again if it does not work is an important skill. He explains that in the building events students build things to
break them. In many cases, the item is going to be tested until it breaks as part of the competition. And if that is not the point of a particular build, students usually wind up making several versions of something such as a catapult and the early models break or do not function properly, so they must rebuild. Outside of Science Olympiad Robert does not see many students doing this. "We don't have kids that tinker. We don't have kids that build stuff to break it and say, 'Oh, that didn't work. What would work?'." He does not see the backyard tinkerer as part of our society today and it means we have students with no clue how things work. "And it really is integrated that if you really want to have innovation and the application of all this neat technology - especially with all the electronics that's coming in now - you have to develop that from a young age so that you get entrepreneurs and people that are willing to tinker."

Robert describes how he teaches students to do a build. He says he starts by asking, "Okay kids, let's read the directions. What are the rules? What are we trying to do here?" He says that having students come up to the high school after doing Science Olympiad in middle school is good because the students have an idea about what they are doing, but the disadvantage is that they want to keep doing the same things they have done before without reading the Division C rules. Getting them to understand that the rules are a little different can be an issue. He uses the Bridge event to explain how the bridge built in Division B can still compete in Division C, but it will not do as well. He tells them, "If you build a 25 -gram bridge that holds the maximum 15 kilograms, this is your score. Whereas, if you build a 10 -gram bridge that holds 10 kilograms, you get a thousand points instead of 600 points." It is about learning the subtleties of design differences. He says part of being a coach is teaching them why arches are better than trusses and how to measure and cut the wood so that it will bend into an arch. The
students typically do not have any background in woodworking or calculating arches, so this process takes a lot of time and patience.

Monetary compensation is disparate in his opinion as mentioned earlier because Science Olympiad runs the whole academic year as opposed to a seasonal sport. He does spend some of his own money to support the program. "Every teacher spends their own money on school supplies and it's no different [with Science Olympiad]." The school does give a budget, but it is for both the middle and upper division to share so it is limited and goes mostly for materials. He says his wife always fusses at him for not turning in his receipts for reimbursement by the school. "But, you know, just last weekend I had to run out and get ten dollars' worth of hardware at the Home Depot and I don't know what happened to that receipt."

Robert lists some of the administrative duties of a coach. "You gotta get parental permission for them to participate, parental permission for photographs, travel requirements, the billing requirements, ordering shirts, getting them to pay for shirts, ordering meals when you're having a workday, you know, accounting for that." Additionally, there are team management issues like who works well together as teammates on a particular project and deciding who goes on first team versus second team. He says it is challenging "just trying to manage the continuation from previous years as well as how to develop new teams and who are good partners and who's really working to support the team and who's just showing up to get credit for it." Robert tries to put people in events they want and are good at doing, but there are certain events that no one wants to do, and the coaches have to assign students to it. As an example, he says, "you have to be able to get the kids to understand that either on a short-term basis or on a long-term basis, somebody has to cover, uh, rocks, you know." The Rocks and Minerals event
required that students take a written test and identify rocks and minerals from either pictures or actual specimens from an official event list (Science Olympiad wiki Rocks and Minerals).

He explains how he will think he has everything settled and the event comes and everything changes. Students suddenly have conflicts, and it is not always with another school activity. He gives the example of a student saying, "Oh, my god, I did not know my parents are taking me out of school for a week to go do college visits. I won't be here for that tournament." It is not as simple as plugging second team students in to fill in for first team students. He explains that there are two people per event at least and a couple of the events have three people. Fifteen students must cover 23 events in pairs or threes and that becomes a balancing act. "Because of these combinations of different events, we may have the two best people for say ornithology but because the people that are in ornithology are in three other events that they are much better in these, second teamers can't replace everything." He says he just tries to optimize the first team to see what kind of performance they can get. "And that is part of the brain damage of who's upset because they didn't get first team." So, when a student cannot make a tournament, Robert has to find someone who can fill all the events that student was in and work well with the partners as well.

And then you get this domino effect because with 15 people and 23 events each of them taking at least two, everybody has nominally an average of about three events per person. So, you domino out one person and suddenly you gotta shuffle everybody around to fill that in. So, we've had some people that have ... easily stepped up or some grudgingly stepped up to fill in some holes that they basically - they can take the study guide from the person that's leaving, but, then, trying to get up to speed is a little bit challenging.

After all of that he can still get the tournament schedule to find that certain events are being held at the same time as other events the same students have entered. Robert says that he has to explain to students sometimes when he moves them from one team to another, "Well, yes, you were a winner in your event but the people that are replacing you are getting medals in three events." He says his second team gets a lot of medals at events. As a team they placed second at an invitational and third at the regional tournament. "Because they're good kids. They're competitive."

Not having their own space and tools is also a time expense because they have to go to another location (middle division makerspace or theater department) and interrupt what they are doing or try to schedule around them. He elaborates more on this when talking about time expense for the students.

A challenge that Robert sees for both science competitions and science education is understanding the concept of STEM. "Because if you think, everybody says, "Oh, we fully support STEM". Well, what do you think that is?" Robert says he has been a member of the American Society of Mechanical Engineers for about 50 years. He credits that organization with inventing the term STEM because they wanted education to concentrate on teaching an integrated technology focus. He says the push for STEM training was to try to get the skills for technology, math, and engineering integrated into the coursework. But that is not what he sees has happened. "People primarily have this check box. Oh yeah, we teach science. Check. Oh yeah, we teach math. Check. Oh yeah, we have computer science - that's technology. Check. Engineering, um, well we've heard of it. Check." He says they treat it like its Ragu, "It's in there." He says that unfortunately many schools have adopted this idea of "Oh, we're college prep and it's pure academics". His response to that is "well pure academics are not bad, but at
some point, you need the application of that to have true value to society." He teaches his students a saying to help them understand how it is all intermingled: "Math uses a language of precision. Science uses math. Engineering applies science."

Robert discusses a personal challenge he faced as a new coach. Because he had not worked as much with the middle school students outside of assisting a few with builds, he did not know their skills or how to match them quickly. The previous head coach had also handled all of the event assignments, so he was not familiar with the process, and it took him a while to get up to speed. "I unfortunately didn't have time to develop that tribal knowledge of the incoming team members. So, we struggled a little bit with that." He says this year has been better.

## Perceived student challenges to participation.

Robert says that recruitment for the high school team is not a difficulty. Because they have had the tradition of a winning middle school team for about eleven years, they have a good base of students coming into the high school each year excited about participating. "The difficulty is they get into high school there's so many other activities between sports and orchestra and debate and you name it." Robert describes the attrition he experienced in the 2021-2022 school year.

We actually had three teams that we registered, but we went from 45 to 31 over the course of the first three or four months. So, we ended up only actually entering any of the tournaments with two teams when we started out with enough people for three with several more people that we thought "coulda/shoulda/woulda" have been part of the team because they participated last year, but they chose for whatever reason - junior year overload or whatever it was - that they backed out.

Robert sees overload as the main reason for this attrition. Robert says that there is not enough time during the day for Science Olympiad preparation. During school time there are 2030 minutes a week allocated to club time. That really is not long enough to accomplish anything for Science Olympiad especially if they are spending part of it walking to the middle school to use the maker space.

We have a huge campus and to walk all the way around the lake to the middle division to barge into their maker space to borrow their tools, and borrow their benches when sometimes they're teaching class during the day when our students might have a study hall that they could go do something for an hour. But instead, the time it takes to walk over there and interrupt another class and borrow a little bit of table space and borrow some tools - it doesn't really lend itself to much daytime support.

Many students are also involved in other clubs doing things at that time. After school are the sports practices, so that conflicts with several students. That basically leaves Saturday as the only time the team can get together to work on things. Of course, the tournaments are also on Saturdays. Other clubs also have Saturday competitions and soccer is mostly on Saturday. He says that it presents a challenge to the students to not have a class time during the school week that they can use to fulfill their Science Olympiad activities. The team sometimes does two or three Saturdays in a row prior to attending an invitational. This cuts into family time for both the students and the coaches. "It really adds up quite a bit." He says they had times over the Christmas holidays they tried to have workdays. He says some of the parents told him, "Well, this is Christmas holiday. We're traveling and, no, we won't be back for you to spend an extra day at Science Olympiad."

Robert explains that sometimes students will be fully active in the fall, but then the winter or spring sports start. "We lost one of our best team members because he - every weekend that we were trying to do workdays - he was away on a soccer tournament." The student made the comment, "I can only do one." Robert says he lost another student who was one of his best biological event competitors when the student was selected for state honors orchestra. Baseball season took one of his best build students and one of the Science Olympiad coaches who was also a baseball coach. "Poof, suddenly we don't get them on weekends because they're always gone to tournaments and games."

While some schools just accept that students involved in sports are not going to be Science Olympiad participants, Robert's school requires all underclassmen to participate in a sport or physical fitness activity. Just like the coaches are sacrificing personal and family time to meet or compete on Saturdays or holidays, the students and their families are also faced with the choice of sacrificing family time or another activity for Science Olympiad. "Unfortunately, a lot of times when students have to pick between a sport and Science Olympiad, even though these are the smartest and best kids around, they're picking the sport." Robert says there is a lot of diversity in interest and activities in his team members. "When you talk about a profile of the students that are actually participating, a lot of them are highly motivated kids that are taking AP classes and things like that and, quite honestly, a lot of them are taking a full load."

Robert explains that the typical student that expresses interest in the fall is one that is taking seven classes (five is considered a full load), a sport, and a performing arts class. He can lose half of those interested students before Christmas. "[It] is the reality hit of getting into the school year and finding that when you take three AP classes, it really does suck up all your free time." So, students who competed all through middle school and would be great contributors to
the team get overwhelmed by the academic load and realize they cannot afford spending a weekend doing Science Olympiad when they need to study for three exams on Monday. "There's so many more distractions in the upper division that it's hard to maintain a full commitment to the Science Olympiad."

Another challenge for the team is that the administration classifies them as a club which means they do not have the full authority of a team. Robert gives an example of the difference between that and a sports team which might miss a half day of school to travel to an event, but if he wants to do that with his club he is told, "Oh, no, you can't leave because that'll interfere with class." He finds this frustrating especially when they may be travelling out of state six hours to attend an invitational. "So, it's a little challenging because we're treated as a club even though we're probably the only team that's competed on a national basis, but we don't necessarily get credit for that."

There is a cost to the student for participation. The travel expenses to tournaments are allocated to the students that are participating. The team does not do fundraising. Robert says this it is common for private schools to not be able to fundraise. "The administrators that are in charge of fundraising are somewhat sensitive to students going out and adding to the nickel and dime requests." As stated previously, the school does give the middle school and high school a combined budget, but it is not enough to cover a trip.

He spends a little time talking about the pros and cons of school size and student opportunities. He acknowledges that large schools are able to have a lot of resources, but there is still a limited number of students that can get to use those resources. For example, he uses a school of 4,000 students. This school may only be able to allow 100 students to participate in Science Olympiad and, though the school can run multiple teams, only one 15-member team can
compete at Regional to go to state. He points out that if instead you had 4 schools with 1,000 students each and 50 students per school participated in Science Olympiad, that is 200 instead of 100 participants and potentially 60 students participating on competitive teams. He uses this to point out that he would like to see more smaller sized schools competing because it gives more students opportunities. He is also illustrating his philosophy that large schools may not serve individual students the best despite having more resources. "But it's hard to find the resources for four schools instead of one and that is kind of the trade-off."

Covid-19 has been a major drawback to the team. "It's brutal trying to do video of the build projects." He also explains how getting together for workdays during quarantine and trying to work masked and keep social distance was difficult. "It had a significant impact on our performance the last two years." Prior to Covid-19, the high school would run two teams and the middle school would run three or four teams. This has not changed that much, but he sees some students being less enthusiastic because of the virtual format. "Virtual tournaments are quite honestly not very interesting because you are all by yourself when you are taking the test." He explains that when the students are there in person, they are there with their teammate testing in the room together and then later running around to watch all the different events and different things together. In the past when the team went to nationals, they would take an extra day and do some sightseeing before coming home. Currently (at the time of this interview) nationals are still virtual. "So, you're back to competing by yourself in a classroom for that event and not quite as thrilling." The state format this year was in person, but it was limited in that everyone had to wear masks and the team could not take the number of extra support people that they like to have. Pre-Covid, the team would have attended 8-10 tournaments a year and it was common for several of those to be out of state. This year they did 4 including the state tournament.

Robert says the students spend most of their time at tournaments socializing as a team. The students do get some exposure to students from other schools during the tournament time, but he would say that $90 \%$ of it is within team socializing. As previously, stated, historically an important part of that socializing for the team has been the one-day side trip that the team took to visit a historic or otherwise educational site. This is important team building time that the students always look forward to yet have missed during the quarantines. His team did win their state competition and attended the "virtual" national competition last year.

## Advice to Those Coaching Science Olympiad

Robert's advice to people considering coaching a Science Olympiad team is, "Run away!". Then he laughs. Robert likes to see more schools becoming involved in Science Olympiad. "It's good for the state that there's a lot more schools that are getting competitive in their performance at these tournaments." Even though it was his school that was unseated, he views it as a positive thing that for the first time in six or seven years a different school won the state tournament the previous year. He would like to see more students having the opportunity to experience Science Olympiad and would like more people to become coaches.
"Having the time to do it is important." He recommends integrating it into the school day as an elective to help lessen the time impact. It is also good to negotiate a dedicated space to store materials and work on builds as well as a budget to buy those materials. He points out, "That would make life a lot easier as a coach having that where you are rather than being a stepchild trying to glom onto something that somebody else owns."

Getting support from the administration to help build school spirit for the team would be desirable and being recognized as a team with the same privileges as a sports team instead of a club should be established from the start. A coach should not have to force their way to the lectern to get the students recognized for their wins.
"For new coaches, you gotta enjoy this." A coach needs to enjoy some aspect of the Science Olympiad. For example, Robert enjoys the builds, but other coaches enjoy mentoring other event types. That helps to spread out the workload as well. Robert recommends getting help. "Any help from parents and other teachers will make life tolerable so you can share the brain damage."

The strategy to winning tournaments is not to win every event or even any events. Instead, your team has to make a decent performance in every single event. The cumulative score of everybody participating is what wins. "And that's one of the things that I try to preach to the kids is this is a team event, and it takes the effort on everybody to do the best they can."

## Appendix P: Sandra's Science Olympiad Experiences

## Introduction and History of Involvement in Science Olympiad.

Sandra was a student participant in Science Olympiad when she was in school and is an example of how participating in Science Olympiad encouraged her into a science field. She began participation in middle school and continued throughout high school.

Sandra first coached the Olympiad as a volunteer at a small public school classified as rural fringe. In the 2020-2021 school year this middle school reported 653 total students and 45.25 teachers with a student to teacher ratio of 14.43 . Race/ethnicity numbers report 251 Black, non-Hispanic; 227 White, non-Hispanic; 98 Hispanic; 55 of two or more races; 16 Asian; 4 American Indian, Alaska Native; and 2 Native Hawaiian, Pacific Islander. The school had 463 students eligible for free or reduced lunch. Sandra talks about her involvement in helping start a Science Olympiad program here as a volunteer. "So, the team - I was the only volunteer coach. And the reason why I got pulled into volunteering there was because my best friend was a science teacher there." Her friend was starting up a Science Olympiad team and she knew Sandra had done Science Olympiad as a student, so she asked Sandra to volunteer. Sandra says she was lucky that the lab she worked at was willing to let her leave early to volunteer. She volunteered there for two years.

Sandra next taught Anatomy and Physiology at a Catholic high school where she was the Science Olympiad coach for two years. In the 2019-2020 school year this school reported 878 total students and 64.3 teachers with a student to teacher ratio of 13.7. Race/ethnicity numbers report 624 White, non-Hispanic; 121 Asian; 117 Hispanic; 8 Black, non-Hispanic; 4 American Indian, Alaska Native; and 4 Native Hawaiian, Pacific Islander. Sandra is currently the Science Olympiad director for state A and has been fulfilling that role for six years.

## Perceived Benefits of Science Olympiad Involvement <br> Personal benefits.

Sandra received a stipend for coaching while she was teaching high school. "When I was coaching at the high school that was necessary just because the Catholic Diocese, they're starting pay is much less than public schools. So, I signed up to sponsor anything I could to get the additional stipend," says Sandra laughing. "I know the coaches in the state have been talking about that because it varies from school to school. The consensus is if the school pays a stipend, it's the same as being a sponsor of a club not a coach's stipend." The point here is that a club sponsor may receive a stipend of a few hundred dollars whereas a sports coach may receive a stipend of $\$ 1000$ or more.

Sandra explains that the stipend was separate from the Science Olympiad budget. The stipend was specifically to go towards her salary and then she had a separate Science Olympiad budget to pay for all the equipment and resources. "That was one of the few things that I didn't have to use my pocket money for," she said. "In my classroom I still had to do that a lot, but not for Science Olympiad."

Sandra's gauge for coaching success changed with the team she was coaching. When she was a volunteer coach for a middle school, she was coaching a brand-new team. Her gauge of success was that students were regularly attending practices. "It showed that they were involved and dedicated and usually that involvement and dedication would show through at the tournaments as well." When she later coached at the high school, the team was established and already had its own definition of success. "They had previously gone to a few national tournaments and had even medaled at some of the national events. So, success for that team, obviously those students who had gone to nationals, success to them was going back to
nationals." She says her gauge of success for the team was that they were having fun. "They had so many other stresses going on. As long as they had fun, I saw that was success."

As a state director, Sandra commented on how she saw other coaches perceiving benefits of the Science Olympiad involvement.

I come into contact with a lot of coaches that really love Science Olympiad and that, even if they were to change school or even if they were to no longer teach, they would still be involved with science Olympiad in some way. But then I also come across a lot of coaches that are only doing Science Olympiad because their administrators told them to.

She sees the latter group typically gaining enthusiasm about Science Olympiad after some time and seeing the value in it. "Especially if they have students that really like Science Olympiad, then they see the value through the kids as well and so they'll put in more time and effort to make sure that their kids are enjoying the experience."

## Perceived student benefits.

Sandra says that Science Olympiad at a minimum provides students with an increased awareness of different areas of science. She points out that most schools only the basic biology, chemistry, and physics classes. "There's so much more out there that students could be aware of and so Science Olympiad kind of helps out with that by going a little deeper into the content areas and perhaps touching on some topics that the students would not have learned in their basic science classes at school."
"Well, now it's a little more common to have like career and tech classes at High Schools," says Sandra, "but before students wouldn't have had much engineering experience. Science Olympiad provided that type of outlet, but now you have a lot of CTE (Career and

Technical Education) programs, so students do get a little more of that without Science Olympiad."
"There will be some students that they have this one written test which is their thing that they focus on - the thing that they love the most."
"A lot of times you'll have students that are devoted to building when they don't do any of the other events," Sandra says. "You see them get into that mode. They test it and it fails, so then they make more modifications and test it - it fails. As long as they keep trying and keep improving, you know they're really into it."

Referring to the Ornithology event (short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U) Sandra gives an example of how digging deeper and student time restraints can lead to students developing specialization within a team competing in an event. "I've seen it happen when one student will just study the sounds. That will be their thing. The other student will do the other stuff." Ornithology includes a great amount of detail. The test is up to $50 \%$ identification of species from the Science Olympiad Official Bird List through pictures, characteristics, or calls. Additionally, students must demonstrate knowledge including diet, behavior, range, distribution, anatomy \& physiology, conversation, and interactions with humans as well as other topics (Science Olympiad wiki Ornithology). Sandra says that the students will use the same strategy when practicing the tests and also doing them in the competition. "Usually on practice days what you see a lot, because of time restraints, is that they will split up the tests," Sandra explains. "One person takes half, and the other person takes half and then if they have questions about their half, they will ask the other person to consult with them." She explains that Ornithology has a natural split in the subject that allows for students to easily divide up the material. "They have like the identification species
and like some questions about it, but then there's also usually an identification from sounds." She says there are other events that also have a natural split of material where each student can specialize in a certain part. She continues to explain how the state credit requirements for students in order to get to college are just basic classes in the sciences and there is so much more out there those students could know. "So, Science Olympiad helps out with that by going a little deeper into the content areas and touching on some topics that are not part of the basic science classes at school."
"Well, every event has at least two students working together, and it really is a great training for the workplace," Sandra says. "You know, in the workplace you may have a whole floor of people who are part of your team, but you may have projects where you're only working with one or two other people at a time." Additionally, she sees Science Olympiad mimicking a larger workplace scenario. "Also, it's supposed to help mimic a scientific community where you have one or two people that you're working on a project with but then you share your results with a whole group of people and you have that feedback," says Sandra. "So, just the experience of having one person that you work closely with and figuring out how to work with that other person on that event is beneficial."

Sandra explains that at invitational tournaments schools can bring more students than just the fifteen-member team.

I ask if the club format fosters leadership by having students serve as officers or something like a team captain and she repsonds, "I have seen where a student will be put in charge of different things like making sure all the other students get their equipment that they need," Sandra says, "or, you know, keeping other students on task with the scheduling. I've seen students have that responsibility."
"So gosh," Sandra says, "you'll see it even with the two-man teams going into an event. You may have one person more organized about information and the other one not." She says when she sits in on events, she often sees them get the test, and one will say, "Okay, here's our game plan. This is what we're going to do." The students are working under a time constraint. She says, "They want to get started and get things done as quickly as possible. That requires some type of leadership for making those quick decisions."

Sandra, in her role as State director confirms, that there are several schools where the Science Olympiad "coach" is just an adult sponsor at the school who signs off on the paperwork and the actual person fulfilling the role of holding team practices, putting together the team and directing students into events is one of the student team members who has taken on that leadership. "That takes leadership, too, because that team captain has to take on those responsibilities that a coach would have." She describes some of the responsibilities as selecting the team members, organizing the team, and handling team registration for tournaments. Teams with an active adult sponsor or coach still provide leadership opportunities for the students. "I have seen where students will be put in charge of different things like making sure all the other students get their equipment that they need or keeping other students on task with the scheduling."
"Well, if they keep coming back to practice, I think that is meaning that they were enjoying the experience," says Sandra. "Because, especially for the Science Olympiad teams where it is after school and it's not a class, I mean, it's really up to the student if they wanted to continue or not." She also cites their willingness and eagerness to try out for a lot of different events and studying on their own as signs that they are enjoying it. "Yeah, so them just showing up, that was a sign that they probably were having a good time or at least enjoying Science

Olympiad and learning stuff from Science Olympiad." She also says that she has seen students get into a mode of testing and it fails and then they make modifcations and it fails and they keep going. "As long as they keep trying and keep improving, you know they're really into it."

Sandra says that they formerly did not have invitationals in her state. Her state did not have any invitationals when she was a student. When schools began holding invitationals, she saw a huge difference in competition. When she was coaching middle school, she says they went to one invitational, but when she was coaching high school, they did at least two invitationals and they had to travel for those. "That made a huge difference between my two experiences. It kind of tightened the competition level as well. Just helped the students get more practice or at least more comfortable with the competition." The unfortunate thing she sees is that the invitationals are mostly held in one large city that with its suburbs straddles the state line and is quite a distance to travel for most of the schools in her state. She says that there may be five to ten invitationals a year held by schools in this city and its suburbs. Due to these numerous opportunities for competition, Sandra says that the schools local to that area "have really taken off and blown everybody else out of the water because they get all that practice in."

Invitationals allow for schools to take more than their 15-member official team to competition. "We kind of used that to not only get them all to practice but also to determine our final team - who would be on the final team."

## Workplace and community support.

The high school where Sandra taught is the Catholic High School into which Laura's (Appendix K) middle school feeds, but the High School program at that time was not receiving the magnitude of community donations that Laura experienced. She did have support from her school. "We had a separate Science Olympiad budget to pay for all the equipment and resources. That core budget came from the administration, but then we also had an extra budget that came
from spirit days." She describes that every Friday was a spirit day. "On spirit day students could pay to not wear their uniforms at the Catholic High School. So, clubs would take turns hosting a spirit day which was just them collecting the money for students who are paying not to wear their uniforms." When it was their Friday, Science Olympiad team members would sell tickets to other students so they would not have to wear their uniforms on those days. "We actually would make several hundred from that."

From her days coaching high school, Sandra found the parents to be very helpful. "The parents were really good about providing stuff for the tournaments." She gives a specific example about travel to one event where she was charged with taking the students. "I was the only coach that went and then it was a bunch of parents. The parents at that high school team, they were really important to, you know, just help make sure the little things were taken care of." She thinks it is easier to keep parents involved in high school who had kids involved in middle school. "They were used to doing that on the middle school teams and so, when they came to high school, they still expect to do that." As the State director, Sandra also recruits volunteers to help with the state tournament. She mentions that some of the parents from her coaching days still help at regional and state tournaments even though they do not have kids participating now.

When Sandra was head coach, her high school ran an invitational. "That was a bit stressful." She said it was nice when people would come and ask her what needed to be done. She especially appreciated the support on the day of the tournament when people would ask "What problems are you having right now that we can help with?" She said she had some teacher and some parents that volunteered. "So, it was really nice. And so in a way it could be considered emotional support just because it helps free up my own mental space a little bit to focus on other things."

She did not take a team to nationals as head coach, but she knows that when the team did go, the parents were very supportive. "The parents pooled together money and paid for it. There was one parent that would buy all the plane tickets on her credit card and then get paid back for most of it." She laughs, "That Catholic High School was the wealthier one in the city."

She says that the administration did not attend the invitational, but they did support it. "Administration was really helpful in making sure that other teachers were willing to let me use their rooms for the tournament." She says that one of the difficulties in hosting a tournament is getting the facilities and spaces. "[Beth (Appendix I)] - she does the Division C tournament, but she'll say that having the support of administration of just letting us use the building for the regional tournament is a big thing because that's actually a big deal for the schools to let us come in and use the whole building the whole day." Sandra points out that it is going to add to the school's electrical costs and custodial costs. "It's a sponsorship in a way when schools let you do that."

Sandra describes the teacher involvement at the middle school where she first volunteer coached. "At that school there was the head coach who was a science teacher, two other science teachers that were also coaches, I was there, and then I think there was another teacher who was in math that helped out." She also describes the teacher involvement at the high school team she coached. "There were three designated coaches but then all the science teachers would help out with whatever events kind of fell in their area. So that would be 7 high school teachers that helped out." She agrees that is a lot of involvement compared to what some schools experience. "Yeah. You know, that's something I still try to wrap my head around." As a state director she can see the big picture of differences between schools. "I'm updating my teacher database of all
the teachers in the state and so I go to all the school websites and seeing one science teacher for grades K through 12, How? How do you do that?"

Unlike coaches from State B who comment on having mentorship from coaches at other schools, ongoing communication, and camaraderie with in the coaching circle, Sandra did not experience this. Even though Sandra experienced a coaching situation with multiple coaches in the same school, she says that there was not much communication between the coaches until it came time to determine which students should be on the team for a competition. She also did not experience much interaction with coaches from other schools while she was coaching. As state director, she has tried to help encourage communication. "I feel like now there is more talking between coaches across schools and I think that's great as long as they think it's great too." She recognizes that not all coaches may want to be social. While being State director, she has a Facebook group for the coaches in her state. "I'd say about half the coaches are on there. It is an easy way for me to share stuff with the coaches and then for the coaches to talk with each other on there." She mentions that two topics of discussion have been the discrepancy between the stipends received at different schools and questions about accommodations for students that need special accommodations. "So, I have that for my coaches and then the state directors also have a Facebook group and we do the same thing on that Facebook group."

Sandra says that community support is most important when you are taking a team to state or national because of the travel expense. State may be across the state for some schools so the travel expense can be akin to attending a national in a neighboring state. National tournaments are often multiple states away and often on one of the coasts. Travel expense issues are further discussed under personal and coaching challenges.

Sandra talks about how most of the publicity for her team was in school. At the high school they would share the results after a tournament in the daily announcements. She also says that the previously described Spirit Days helped get their name out as a club through publicity in the school paper. "I wish that it could get as much publicity and notoriety as the sports do." Sandra states that it was one of the goals of the people who started the national Science Olympiad program for it to be something that would be equivalent to sports. "It is, when you look at it, a team - the number of people you have on there, the Science Olympiad season is actually longer than any sports season, but so far I think that's where the similarities end." She does not see the funding and notoriety between the two being equivalent.
"I remember when I was a student, our local paper would report on Science Olympiad", says Sandra. "They don't really do that anymore. I know school bulletins will include information about Science Olympiad." She also says that some of the teams occasionally get sponsorships from local organizations. "I think there are some science organizations - they've given some scholarships to students or scholarship money to the teams going to Nationals as well. Trying to remember if Rotary or Keys or Lions has anything." She thinks that some of the large city teams have received some sponsorship from companies in the city when they went to Nationals.

## Perceived Challenges of Science Olympiad Involvement Personal and coaching challenges.

Sandra believes that middle school is the critical time for Science Olympiad recruitment.
She can only speak about recruitment from the points of view of a student who was recruited and a state director who observes the coaches in her state as well as other states. Since Sandra was a volunteer with the middle school, she was not involved in recruiting students because the teachers handled that. She did not do much recruiting as a high school coach either because the
team was mostly comprised of students who competed in middle school. That was how she became involved as a student. "The kids I competed with in high school, it's because we got recruited to do it in middle school and then we just continued on through high school." She also feels that the approachability of the coaches plays a critical role at this age. "So, really the middle school coaches are the biggest recruiters to get Science Olympiad students and I'd say a lot of that time middle school students get involved because they like the teacher." Some ways that she knows middle school teachers use to introduce students to Science Olympiad is to mention it is class and to hold informational meetings. Sometimes students join because they have an older sibling who is involved and so they are also interested in competing.

Sandra acknowledges that "bribing" students with food is an effective technique and knows that many coaches use it to get kids to come to the first informational meeting. She also mentions that extra credit is another way to entice them. When she coached high school, she found that the students were key. "Really the biggest recruiter was the students who did it in middle school and they come to the high school and continue doing it."

Coaching duties vary by school according to Sandra's observations. "It is a little different at each school, but when I was head coach at high school the head coach was in charge of registering the team, taking care of all the finances, communicating with the state director, and then getting all the information about the tournaments and the events." Her assistant coaches were in charge of helping students with specific events. She had an assistant coach who was in charge of the building events and made sure that the students had the materials they needed. The assistant coaches would also be at the tournaments to make sure the students were getting to their events.

Teams are limited to fifteen students to cover 23 events. All events expect students to compete in teams of two with some allowing for teams of three. This means that most students need to be able to compete in 2 to 3 different events in order for the team to be competitive. The limitation means that if there are many students wanting to participate, they may not all be able to be on the final team. "You have one official team kind of because at a qualifying tournament only one team from each school can compete," Sandra says. "Since we went to invitational tournaments, we did have two teams because usually you can take multiple teams. We used that to not only get them all to practice but also to determine who would be on the final team."

Sandra says that in her state schools are separated into large and small school categories for the state tournament. Team and category awards are given for each category. However, to determine who is going to the national tournament, all of the teams in both categories are put together for an overall ranking. In State A the regionals are qualifiers for the state tournament. However, not all states require a team to qualify at a regional before attending state.

The number of teams a state can send to nationals is determined by the national office. Sandra explains. "Most of the states in the Midwest only send one team. It's based on how many schools total you have competing." This, of course, differs from states with higher populations. She explains using California as an example. "California split into Northern California and Southern California and then both of those send two teams per division because they have so many schools. And then whichever state is hosting nationals also gets to send two teams that year." She elaborates further on the structure:

Every state, their state tournament is the qualifier for nationals. Some states also do regionals as qualifiers for state. [State A] has regionals as a qualifier tournament. So, all [State A] schools have to compete in a regional tournament
and then usually about our top half of teams from each regional goes on to the state tournament. And then there's also the invitationals. The invitationals are just practice tournaments that the schools will put on. I don't know about [State C]. I know Nebraska. They have regional tournaments, but their regional tournaments are not qualifiers for state. So even [State A] teams can go up and compete in their regional tournaments. They kind of treat their regionals as invitationals.

Sandra explains how a regional competition can be run simultaneous to an invitational. "The scoring is put in a different category. The invitational team has a special like number or identifier so that the people running the event know to keep that test and that score separate from the others." She says that the awards for the invitationals are also kept separate from the awards for the Regionals and since there usually are not many invitational teams, they usually just award a ribbon to first place.

Sandra describes her process for putting together a team. First, she had the students that came to practice on the list as possibilities for the events they were practicing. "I kept note of attendance and that would influence who made the team as well." She says that she also noted attitudes. "If there's a kid that was having an attitude problem, I probably wouldn't put him on the team because I wouldn't want to deal with that." As they took practice tests, she noted the ones that seem to really catch on and do the best. "I have students ranked for each event, but for each student I would rank the events for them." And then it depended on how the tournament schedule was put together as to the combination of events a student gets. "I would have them in their top event no matter what. And if they had a conflict with another at that time, it didn't matter. They were in their top event."

Sandra provided an example of a student who was a challenge for her. He was rather picky about his partner and very vocal about it if he felt they were going to pull him down in the event. "I often didn’t want to deal with it. So, I would just have him go into an event by himself." That is an option. The Science Olympiad encourages competition in pairs, but there is not a rule against a student competing alone in an event. Sandra says she did pair him when she could. "He did have a few friends who were good at accommodating that side of him. So, if they were willing to be in an event with him, I would put them in the event with him." This also illustrates students learning to work together which was previously mentioned.

Sandra allowed students who did not compete well enough at invitational tournament to be put on the final competition team for regional or state to be alternates so that they could still attend the tournaments. "They could at least be alternates and go to the tournaments and help out the team by like taking equipment back and forth." She also believes that letting students experience the tournament and see what it was like would make them want to try out the next year.
"I don't think there is any school that will turn away a kid," says Sandra. "If they didn't make the final team of 15 , they could at least be alternates and go to the tournaments and help out the team by like taking equipment back and forth." Some schools run multiple teams to allow students not on the official team to still compete. Sandra states the value of this, "Just experiencing the tournament in order to see what it'll be like so maybe they would still try out the next year."

Sandra says that when she was coaching at middle school, she felt that she was starting at ground zero with some of the students. This can make it difficult to figure out which events to put students in for competition. "When I was coaching the middle school team was before we
got our new science standards so some of that science was not pushed as much at younger ages." She says that you need to consider what the students already know or what their interests are. "So obviously, there's a lot of kids that like fossils events because they liked dinosaurs when they were little", she laughs. She says sometimes they do not know anything about any of the events. Sandra thinks there is more flexibility in high school because the students have gained enough basic knowledge that they can build on it for any event they choose.

As state director Sandra often connects with other state directors. This gives her an added perspective on the expense of travel for competitions. Bussing may be a major expense for schools in the main 48 states, but she gives an interesting perspective on travel difficulties that she learned about by talking with the Hawaii state director. "They have teams on all of the islands. So those teams must fly to go to their state tournament. That's several thousand for them just to go to the state tournament each year." That puts their state tournament nearly on par with what most teams would have to pay to attend Nationals. In response to the expense of taking a team to nationals, Sandra says, "Oh, gosh! I have no idea" since she did not take her team to Nationals as a coach. She does have some knowledge about the required funding from taking note of some of the issues teams in her state experience when going. Sandra continues to explain that there is more to attending Nationals than just getting the participants there and housing them. "Then the building devices have to be shipped to the tournaments. Some teams will pay to ship that material on a plane or some teams will rent a van and drive it. It's pretty expensive to go to national tournaments."

There is a level of transportation that is necessary for any tournament even if it just the next town over. Sandra relates a story about how one time the school she was at gave her the
worst bus they had to take to a meet which wound up leaving them stranded. "It kept breaking down," she recounts. "It was horrible. We had a foot of snow and no heater on that bus."
"Unfortunately, at some schools there may be only one teacher that wants to coach and lead. They may be great at organizing the students, getting information to their students," Sandra says when asked to describe factors that are crucial for the success of a team. A thing that she sees in her state that makes a huge difference is having a lot of coaches. "You really need to have somebody to devote their time with each student to help them practice and understand the rules. And when you only have one coach doing that it's really hard." She explains that it does not matter if the one coach has knowledge of all the event categories. The problem is enough time to spend with the students on individual events. She thinks that in the situation where the team has only one coach, the coach is typically spread too thin and cannot give any one group enough mentoring and the result is just chaos. "You have some students that are great at practicing on their own, but you have even more students that still need guidance." If there are multiple people coaching, each coach can schedule one day each week to work with the students involved in one or two events. This allows for that time to be very focused and more efficiently used.

Sandra remarked that she never tracked the hours she put into coaching, but it was common for her to be the last one to leave the building at about 7:00 PM. She says this was true "especially during the Science Olympiad season, you know, Science Olympiad immediately after school with the kids and then I would stay later to prep the labs, grade papers, and such." She explains her perspective on coach burnout. "I see a lot of coaches, especially older coaches, that will leave," says Sandra. "And it's usually not because of Science Olympiad or the students. It's usually because of just the other responsibilities that are put on to them at the school. All the
administrative tasks that they have to do." Some examples of these tasks she gives are accreditation for schools, or standards changing and having to redesign their curriculum, and recently the switching to online schooling during COVID. "Even from when I was teaching to now - it seems like there's way more things that teachers have to take care of as part of their job. It takes a lot of time."

Despite the hours, Sandra feels that most Science Olympiad coaches have a positive experience. There are some coaches she has met who are only coaching Science Olympiad because their administrators to them to do it. However, most of the coaches she has had contact with love Science Olympiad and would still be involved with it in some way even if they were to change schools or no longer teach. "Very, very rarely do I feel a coach really does not like being a coach and are having a horrible experience." She says that it does happen and she has had coaches contact her about it. She tells them, "Well then, don't coach." Sandra says that if the students are really wanting to do Science Olympiad, they will find someone. They may convince a parent to volunteer or one of the students may take on the role as previously mentioned.

When asked what new challenges Covid was creating for Science Olympiad in her state, Sandra responded:

Overall, my attitude with Science Olympiad hasn't changed that much with COVID. It's always has been a sort of love-hate relationship. I absolutely love the program, all it has to offer, and working with the coaches and students, but I hate the many stressors that go into running the program (funding, being able to use facilities, getting enough volunteers, dealing with complaints). Those have not changed. However, something I have noticed is that everybody is tired. Volunteers are tired (and many just aren't volunteering anymore), the coaches are tired, the students are tired, I'm tired. People are constantly telling me
how excited they are to still have SO (especially for all [StateA] tournaments to be back in-person this year), but some of those same people have also bowed out of helping this year (for reasons I can understand). And others just won't (for reasons I understand). I worry about it pushing my volunteers who have continued to quicker burnout as they are also noticing the lack of help and are trying to fill the void.

## Perceived student challenges to participation.

"The burn out. Gosh! There's so many factors that can contribute to the burnout, um, just so many things that students deal with," says Sandra. "I did see that when I was a high school coach. Some of the students who had gone for so many years, they just got tired from the other pressures in high school that they quit Science Olympiad." There is the competition pressure of "I gotta do well in this event so I [earn a] medal, but then there's also the pressure of we don't want to completely flake out because you're going to affect the whole team." So, she says that students can get stressed on the day of the tournament and get tournament burnout, but she sees other things being more responsible for burnout. She lists some of these pressures. "High school kids that have jobs, maybe other family pressures, other after-school programs they're involved in, homework - all that working together." She says that just trying to stay afloat in all of that is enough to cause burnout.

In response to a comment about there being a hyper focus on winning Sandra comments, "I think you have a few teams who have won and have come to expect that they'll win. And then you may have a few students and other teams that are that way, too." When asked if that is a drawback or not, she says, "Well it definitely raises the level of competitiveness and level of competition which, for the teams that go to National, that's needed." She describes how in some other states the most competitive teams are from schools that are science and math focused.
"You know that this is what they learn all day is doing this stuff. For our students to be able to compete against them, they have to be focused on winning if they want to win."
"I mean, there's definitely drawbacks because [completing] puts a lot of stress on themselves. It also puts a lot of stress on their teammates if their teammates are not as up there as they are. It also puts stress on teachers and parents," says Sandra. "So, teachers who just have to deal with this student that's overly stressed stresses out the teacher, too." She has already discussed the example of how she had to deal with the overly competitive student who was picky about his partners because he did not want them to pull him down. Going back to her own competing days, Sandra tells a story about an event where she was the one pulling down the score. "I was the lower level, but we both went into that expecting it, so it was fine." She laughs, "I didn't feel bad and he didn't get too upset with me, so it was OK." She does not think she has specifically seen or heard anybody tell her about a specific instance where a student has felt inadequate because of not doing well at Science Olympiad competition.

Sandra thinks that the prep time depends on the students' personal tendency to study and the arrangement at the school. "It depends on the school," says Sandra. "If you have a school where you have limited coaches and the team meets together once or twice a week, then they're probably meeting one or two hours a week." However, if the team is lucky enough to have multiple coaches doing the events, then it can vary. This was the case when she was competing. "When I was a student in Science Olympiad, we had practices every day after school for an hour to an hour and a half." She points out there are also schools where Science Olympiad events are tied into their science curriculum. "Like they might actually have an elective class that's dedicated to Science Olympiad. So, then those students are doing Science Olympiad during the day in their class. So, it really depends on the school and how they handle it." It varies by
student too. Some students will only practice when the team is having practice and then some kids prefer practicing on their own so they may go home and study for several hours on their own.

She expects that the builds take more time. "Because they have to build the device, test it, which usually means breaking it, and then rebuild it, test it, break it, rebuild it and so I would naturally assume that takes more time." However, students who are studying for written tests may be putting in as much time, but it is not as visible. As mentioned before in student benefits, there are some students who will have the one written test event topic that is their love. In Sandra's experience these are usually identification events. She explains that ornithology, insects, and invasive species each stay for two years and then rotate. "So, you'll have some students that just love those ones and they will study nonstop." She has even known students to join the professional organizations that study those particular topics and attend meetings of that organization. "Obviously, these students have put in a lot of time to learning that event and you can usually tell which students these are because if they don't take first place they're absolutely crushed."

Sandra also knows that students have conflicts with other activities. She says that the students competing in SO in her state are rather diverse in their interests, but athletes are typically not part of the SO team. She has done some research on athletics and Science Olympiad and so has a pretty good feel for the overlap and conflicts students encounter. She says their practice and game schedules just conflict too much. "Usually not athletes, though, just because the schedules conflict so much." "But that's not always true," she continues. "Like the small schools out in the western part of the state where the students do and participate in everything, you'll have athletes that also do Science Olympiad." This is mostly due to the fact that the
student body is so small that if students are involved in nearly every activity the activities do not exist.

## Advice to Those Coaching Science Olympiad

As a state director Sandra noted several practices that seem to give some teams a competitive edge. She notes that the schools that attend more invitationals and get more practice tend to win. "Definitely what I've learned over the years: doing the invitational tournaments getting those practices. And that makes a huge difference." The second thing that she has observed is that schools with multiple mentors specializing in their events give their team advantages in those events. In talking about the one coach trying to do it all she says, "They may have a lot of knowledge of all the events, but you really need to have somebody to devote their time with each student to help them practice and understand the rules." She says these mentors can be recruited from the other teachers in the math and science department, the school at large, and from willing parents. "So really, having multiple people to help coach helps out especially when that allows you to come up with a schedule - the practice schedule- where you have designated days for designated events." Having designated practices is another thing she recommends. "That way you can really have the students focus on those events that day." She says it is not as productive when one coach tries to have the whole team practicing everything at the same time. "It's just mass chaos when that happens." As mentioned previously, Sandra does not try to convince coaches in her state to keep coaching if they are miserable doing it. She advises that if it is just for the stipend and you are having a horrible experience, then do not do it. However, she does recommend giving coaching a try. She says that she has seen coaches who started just because of the stipend or it was part of their job description and who fell in love with Science Olympiad.

## Appendix Q: Scott's Science Olympiad Experiences

## Introduction

Scott started his first Science Olympiad team at a public High school for grade 9-12 which is characterized as Rural distant. School data for the year 2019-2020 gave 110 total students and 10.33 teachers with a student to teacher ratio of 10.65 . Race/ethnicity numbers report 103 White, non-Hispanic; 3 Asian; 2 Black, non-Hispanic; and 1 American Indian, Alaska Native. This is the second to smallest middle school discussed in this study.

Scott's second school was a public school where he teaches at the Middle school, but coaches both the Middle school and High school teams as part of a coaching team. The Middle school is characterized as Town distant. School data for the year 2019-2020 gave 826 total students and 52.24 teachers with a 14.69 student to teacher ratio. Race/ethnicity numbers report 661 White, non-Hispanic; 70 two or more races; 35 Black, non-Hispanic; 35 Hispanic; 15 Asian; 7 Native Hawaiian, Pacific Islander; and 3 American Indian, Alaska Native. This is the largest Middle school represented in this study.

The High school is characterized as Town distant. School data for the year 2019-2020 gave 941 total students and 61.63 teachers with a student to teacher ratio of 15.27. Race/ethnicity numbers report 733 White, non-Hispanic; 77 two or more races; 55 Hispanic; 41 Black, non-Hispanic; 19 Asian; 12 Native Hawaiian, Pacific Islander; 4 American Indian, Alaska Native. This is the largest High school discussed in this study.

## History of Involvement in Science Olympiad

The first thing that is most obvious about Scott is his enthusiasm for Science Olympiad and the opportunities it offers students. In his nineteen years of coaching, he has seen involvement in Science Olympiad change students and set them on career paths in STEM related fields. Scott started as an alternative certification teacher. While going through that program at
a university in State B during his first year of teaching, he met someone who did Science Olympiad. He thought it sounded interesting and decided to do it. "I started my first year with about four or five kids." He says that he had no idea what they were doing, but they did what they could which was a few events at the regional meet that year. "It was a pretty - not mind blowing, but pretty, pretty large realization that we needed more kids and we needed more events covered to go anywhere." The next year he had some students win their events at regionals. This was before individual event winners were allowed to move on to state. At that time only teams were allowed to move on to state and not individual winners, so the regional competition was as far as they could go.

His third year he moved to his current school and started a middle school team with seven or eight kids. "I was a little bit more prepared, and we ended up doing the same thing." He says that the students won four or five events, but the team came in fifth or sixth just below the cut to move on to state. "So, we were still, I would say, in the toddler stage of the program, but we were learning the ropes." He says there were two schools in his region at that time who basically traded $1^{\text {st }}$ and $2^{\text {nd }}$ team placings back and forth each year. "We had parents and myself - we watched those teams like a hawk because they were essentially the big bullies on the block." The fourth year his team made it to state and then he figured out the strategy these two schools were using. "I figured out that we need to double entry as many events as we can that were allowed because all [those two schools] were doing is they were taking those third place points away from other schools to cushion their lead." The fifth year his team beat one of the schools to take second place. In the sixth year, his division B (middle school) team beat both schools to get first place. The school that they had beaten twice petitioned to change regions. So, then his team and the remaining school of the two traded places back and forth until that coach took a
different job and left Science Olympiad coaching. His team won the regionals nine years in a row prior to 2020 when the tournament for that region was dissolved and the schools in the region were divided amongst the other regions in the state.

Scott talks about how he got started taking teams to invitationals. "I started traveling with the teams to the [large city in State B] meets I think my third year realizing that we couldn't just do Regional. We had to do these pre-tournaments like the ones in [large city in State C] and [large city in State B]." He took his team to those for about seven years. Then people began asking him "When are you guys going to host one?" He said that the calendar in his state was pretty set to where he could not start hosting an additional meet. "Then my friend at another school retired and he ran a combined $B / C$ meet. So, the following year, we decided to run a combined B/C meet." He explains how at that time schools either held a B (middle school) or C (high school) meet and there were no combined B/C meets. "Well, that first year, we ended up having a little over a thousand students from six states including [the State C Champion]. The Iowa State Champion, and the Nebraska State Champion brought both their B and their C teams."

Scott continues, "We ran an open format which meant that the events ran all day. Once the kids were done, they could move on to their next meet. Which was a hard thing to get across to the more regimented schools." In talking to the schools at the coaches' meeting at the end of the day, he found that that was the most successful way and the participating schools liked it. "If you have a kid that wants to do seven events and try and squeeze them in so they can get that experience, then why not? That's kind of the whole point." He says that one of his coach friends who brought a team from Ames, Iowa brought both her B and C teams. She told him, "If you don't run a B/C meet, we won't be back." After that he felt that it was their obligation from then
on out to run a $\mathrm{B} / \mathrm{C}$ meet because it was not only advantageous to the small schools in their area who may only compete in that meet before regionals, but also to those out-of-state teams, that want to bring both of their teams to get them more experience. Since some schools have viewed his teams' successes grudgingly and since they replaced the former "bullies on the block" in some viewpoints, he likes to think this meet puts a more positive perspective. "I guess, we've morphed into not only the bully on the block, but a good bully that provides a big service. Last year we had 69 teams from 52 schools and about 1400 kids which was the maximum." To enhance the value of that service, he says that they have moved the meet to December to fill a hole earlier in the year. "We were traditionally the tune-up before Regionals, which everybody liked, but now we're going to be the first big meet where those smaller schools can come in December and get some practice that they can work on over Christmas."

## Perceived Benefits of Science Olympiad Involvement Personal benefits to the coach/teacher.

Scott says that there were several coaches that helped him get started. "I owe those coaches tremendously." One of those coaches jokingly told him once, "All you did was beat us, you know. If we'd have known that, we wouldn't have helped you." He says that he has developed some really close friendships with other Science Olympiad coaches. "Some of my closest friends in the field of Science come about due to Science Olympiad and I not only consider them peers and coaches I've learned from, but I consider them friends." He says that he has seen some of the other coaches over the years on a regular basis outside of school and outside of Science Olympiad and some of them he only sees at tournaments. A change in tournament structure in recent years has been the addition of a lunch break into the schedule. "A nice benefit from this is that I have been able to sit down and eat lunch and have more in-depth, more personal conversations with some of those coaches."

Scott discusses the importance and quality of interaction with other coaches for him: Oh, it's absolutely top-notch. Some of my closest friends in the field of science came about due to Science Olympiad and I not only consider them peers and coaches I've learned from, but I consider them friends. Some of them, over the years, I've seen on a regular basis outside of school and outside of Science Olympiad and some of them, I only see them at the meets, but we cherish that time. We're - I don't want to call us a unique set because there are other programs that do this too, but we're - we're a unique set.

Scott explains that tournaments often run nonstop from 8:30 in the morning to $1: 30$ or 2:00 in the afternoon, however the last couple of years, some of the schools have started putting a break in. "And the guise for doing that is for the kids so that the kids can actually find time to eat under a semi normal situation so they're not stressed about when they can go eat lunch." For him that has provided a nice side benefit. "I have been able to sit down and eat lunch and have more in-depth, more personal conversations with some of those coaches."

And in his turn, Scott became a mentor to other coaches. He says that there are other academic competition programs, but as far as he knows, Science Olympiad is the only one that goes the whole school year. Often new schools do not understand this and not know about the invitational. So, they will just practice two weeks before the regional tournaments and then they are done. He said that he was in his third year of coaching before he realized the importance of invitationals. He and some of the other coaches try to partner with some of the new schools. He tells them, "If you really want to be successful, lean on us. We've got the experience. We'll share tests with you." He says all the teams do a lot of sharing of old tests and it helps expand the program for new schools when they are able to take advantage of that. Because of this he
says, "I've developed some very close relationships with some of the smaller schools in the region."

Scott does receive a stipend, but he does not consider it a major benefit. "I will openly admit that we are the most underpaid Science Olympiad coaches in the region." Therefore, this topic will be further addressed in the Personal and Coaching Challenges section.

For Scott Science Olympiad is what keeps him going in teaching. "I don't do Science Olympiad so I can teach. I teach so I can do Science Olympiad." He thinks the vast majority of coaches are in it because that is where their heart is. "They want those kids to experience the 23 different events of their choosing. They want them to do that, and they want them to do well."

Scott says he would like to say that he has coached a successful team every year, but there have been some years when the team did not win. He specifically mentions that one year before he got the assistant coach the middle school team took 2nd place. Then he talks about how in 2000 prior to COVID his regional competition was suddenly changed by the state. They had to go to a different regional and they took a smaller team than they normally would and they placed fourth which did still qualify them for state but was not their standard performance."This year was probably where getting to state was the objective and not it's an expectation to get to state."

Scott says that superficially his gauge of success in winning medals at State. Beyond that he says that he feels he has coached a successful team every year. "So, I think personally that the life experiences that the kids get is, at minimum, equally as important." He thinks his assistant coach would agree with him. "Winning events at regionals and potentially state is the icing on the cake that they've built through the whole year, and I like icing." He laughs.

## Perceived student benefits.

Scott sees Science Olympiad providing students in medium and small schools an outlet that they might not otherwise have. He says that in his state the largest schools in the big cities do not compete in Science Olympiad. "They have so many other options like Quiz Bowl and Math competition." He says his school could do those as well, but he thinks Science Olympiad is a program that depends less on school size than some of the others. Although he experiences some disadvantages at his first school due to its small size, he gives the example of a friend who has maintained a successful team at a similar sized small school. The coach there is providing the students with Science Olympiad as an opportunity for something to keep them interested in science as well as something for them to do because that town is rural and not close enough to a large city for the students to have many opportunities.

Giving students opportunities is important to Scott and particularly giving girls opportunities to experience science is important to him. "A colleague of mine said seventh grade is typically the year where boys and girls split. The girls typically end up not liking science and the boys continue doing science." Scott thinks that Science Olympiad helps change that and explains how Science Olympiad keeps girls involved in science while regular classroom science does not.

We just provide them the opportunity to individualize events so they're not put in a stressful situation that they might not want to be working in. They get to choose who they want to team with and which events they want to do. Regardless of gender, we let kids choose their events. We might try to steer them towards certain events we think they will do well in based on how they do in classes or personal interests we know about, but going into that first meet, it's fair game. I
tell them that if they want to compete in 10 events and they can squeeze it all in, then go for it.

Scott tries to take his team to as many invitationals as possible. "The goal of the premeets is to get the kids the experience and let them decide whether they really like those events or not," Scott uses the term pre-meet for what the other coaches call invitationals. These are any meets or tournaments other than Regional or State. The invitationals in State B allow for schools to enter one large team and do not require entry of multiple teams if the team member number exceeds fifteen. He thinks this is a great benefit to the students and the team. He and the other coaches tell the students early in the year, "We don't care if we win the meet. We're there to get you experience." This gives the students all an equal opportunity to compete and win medals. Scotts says that he uses the results from these early invitationals. "That helps us sort out who we can steer towards certain events in the regional teams." He relates the case of an eighth grader who joined the team late in the season when there were only two invitationals left before regionals. "She, out of nowhere, just ended up blowing away all the competition including our established pair in that certain event." She was placed on the second team for regionals and won the event there, so she got to move on to state as an individual. "So, we've had kids come in late and do well, kids come in late and not do well, but we're still giving them that experience." He does not discourage anyone from joining. "The more kids we have the better."

It is a benefit to both the student and the team to give as many students as possible competition opportunities. Scott says that they can get a lot of $6^{\text {th }}$ graders interested in Science Olympiad, but they must keep them involved so they stay part of the team. He tells them, "You're not quite on the top team this year, but you're still going to regional to give you that experience." He says, "That has lit the fire in their eyes so to speak."

Scott says, "I'm still in contact with every single one of my very first group of kids from middle school. Some are finishing up their PhD's. Some have their PhD's. They're professional." He talks about how one of the most brilliant students he ever had got his Master's in Business. He said he saw him one time and said, "You're wasting your skills doing that. You have a science mind. You need to use it that way." Scott does not think there is anything wrong with business, but to him this student was the epitome of the lab scientist. In the end Scott says, "He ended up getting his PhD in physics."

Scott continues, "Another one of those early students went to law school at Harvard then finished at Yale. He is a Native American lawyer who advocates for indigenous rights associated with environmental issues. So, he puts his science background to work there."

Scott estimates that 40 to 50 percent of the students that have competed on his regional and state teams have gone on into science fields. For the students that do not make those teams, but stick with Science Olympiad, he thinks about 25-35 percent have continued into science fields. "I think a lot of that is the kids I get in Science Olympiad already have that vocation of moving on to science in their college career."

Science Olympiad seems to attract the students that are already involved or interested in science. Scott says that he does have some students that do not fit the expected mold. For example, he says that over the past three to four years he has had some students who dress Goth really get into the program. "In fact, we have a young lady who - she's top notch. She dresses Goth, but she likes science and she's gonna go into college and do something in science."
"We take all comers." Scott says they always tell the students, "If you can hang on to this program, hang out with us, and make it to the first meet, we've got you hooked." He says
that it is a long time to maintain the interest of middle-schoolers from September until the first meet in November.

To build enthusiasm and maintain interest in the fall before the first tournament, Scott likes to hold mini competitions for some of the practices. It was originally one of his assistance coach's idea and they have done it for years. They pick one event for the practice. Scott has everyone participate even if they are not planning to enter that event. "The kids love that." He says that it is hard to squeeze it into the time constraints. "A typical event at regional takes 50 minutes. So, we have barely enough time by the time buses are called, the kids are situated, and they've got their chrome books out and logged in." He says that they need to remind the students earlier in the week which event it is so the students can be ready. He also must have things ready for the students to jump right into it. For example, he uses the event Keep the Heat where the student needs to use heated water as part of the test, so he will have the water ready to go ahead of time. He says that they try to rotate the featured event each time they do these mini competitions so that students get to experience what different event topics are like and, hopefully, expand students' interests beyond just a couple of events. It also provides early competition practice for the students who are most likely to enter each of those events.

Scott sees evidence for improved classroom performance from Science Olympiad participation. "Yes, definitely," says Scott. "The building events help them to be more comfortable in shop class, so they are willing to attempt something a little more complex. The meteorology kids are going to ace the test on that section." He has a specific example of this. "Um, the first time we won at State, two kids had asked me beforehand that if they won in Meteorology, could they sleep in class through the meteorology unit." Scott decided to make that deal with them and then they won. "And so, for the first part of meteorology they put their
heads down and went to sleep. I left them, but after that they jumped in and helped." Scott also thinks that there are benefits beyond content for the students. "The hours they put in preparing notes for Science Olympiad helps them become more efficient, studious students for school for their everyday classes. And the test scores, they show that, I think, across the board they reflect that.

The Meteorology event is currently a Division B only event. It consists of a written test for a team of two which focuses on students demonstrating an understanding of basic meteorological principles and show the ability to interpret and analyze meteorological data. The main topic rotates each year between Climate, Everyday Weather, and Severe Storms (Science Olympiad wiki Meteorology). Short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U. "Yeah," Scott says, "There's a direct correlation between the content you learn and use in Science Olympiad and the classroom across the majority of the events. I've heard kids talking about covering things in class that they had seen on an event test."
"I'm at the middle school, so the high school team is pretty much left on their own," says Scott. "I have a young lady who is pretty efficient with organizing the materials. So, she'll come and organize our supplies. She actually proposed that this year we run it more like a club and have dedicated officers." He says that one of her goals is to make Science Olympiad something they can varsity letter in at their school.

Scott says that seeing their excitement when they do well at meets is evidence for him that they are enjoying the experience, "Seeing them run down the stairs and not trip while they run to get their medals at meets (laughs). Um, and then texting their parents and taking a picture right away."

When asked about the effects of the competition on the students, most coaches do view it as the motivating factor. Having a competition to prepare for provides a framework for goal setting for the student. Scott says, "I think that's probably one of the best experiences I've seen in my teaching and giving the kids is that experience of 'Man, we did poorly,' and then they're called for second place." He says that little surprise makes them think, "Wow, I guess we didn't do as poorly as - as the other schools." He likes to take that little bit of negativity about maybe everyone did bad and make them rethink it. He says he will tell them, "Well, maybe you just did a lot better than you thought."

Scott says he sees the students develop self-awareness and efficiency. "You have to be efficient or you're not going to do well." He tells the students that they cannot expect to build something the night before and have it do well in competition. It teaches them that they must be prepared. He says that a lot of it is also the kids seeing the life lessons. He uses an example from the MagLev event where students build a magnetic levitated vehicle and accurately predict the time their car will take to run a course. The team also takes a test over magnetism and some electricity topics (Science Olympiad wiki MagLev). The students realized they were not going to get the vehicle built in time. Scott says that he told them to focus on the paper test part of the event. In reading the rules, it stated that the students "may bring up to two maglevs". Scott interpreted this as the vehicle was optional and, therefore, the students could still compete even if they took some deductions for not having a vehicle since the word may was used. He says the students placed high enough on the test to have placed third overall at regionals without the vehicle, but the state director at the time disqualified them because she insisted that the event required at least one vehicle. There was less than a month between regionals and state, so Scott says that the students got busy building a working MagLev and took fifth or sixth place at state.

He says there have been other instances over the years. "Um, we've been ruled against at the Regional and State level where - I have more at the State - where I absolutely in my heart felt it was the wrong decision and it hurts to see a kid's reaction to that." He describes the kids talking about how unfair they think it is and he asks them, "We know now. How are we going to take care of this?" Scott says those are experiences that help build that character. "I think the building of character and that efficiency I talked about, and the preparedness pays dividends for the leadership qualities they'll need in life."

Scott tries to act more as a coordinator and let the students be self-sufficient. He says that he currently has a yond lady who is very efficient at organizing materials and he has her come and do the middle school supplies as well. "Especially for the Chemistry-based events just to make sure everything's working and clean and she'll enlist the middle school kids." She has proposed that for the next school year they run Science Olympiad like a club that has dedicated officers. He says that she would be a natural choice for president not just because she has organizational skills. "She is not afraid to question our decisions." He mentions the issue with deciding who will be on the regional team that is explained under Personal and Coaching Challenges. She became a spokesperson for the team and questioned some of the coaches' decisions. "She's very good at doing that."

In discussing team recruitment at the beginning of school and team structure, Scott says, "If I have 30 middle school kids show up, then we'll immediately pay that second entry for regionals and state and we'll let it be known to the kids that we're entering two teams." This is one of the newer benefits that he and other coaches in his state pushed to have enacted. The state now allows two teams per school to be entered into the regional competition. He uses this to encourage the newer members who may be doubting their abilities to stay involved. He tells
them, "So, it benefits you to stay in and do this because you may or may not be on the top team, but you're going to regionals anyway." He explains that the repeating State champion schools in both his state and a neighboring state pretty much have their top team membership established by January or February. This used to exclude all but the top 15 from participating in anything other than an invitational during most of the spring semester. Changes in his state SO rules mean that now the regional competition allows schools to enter up to two teams and individuals in excess of the 15 -member team can advance to State if they win. "So, you have those kids that may not make the top team but are still good in their events. And now if they win their event at regionals, they can move on to the State competition."

Scott is passionate about giving students as much opportunity as possible to compete and excel. He explains in greater detail how he has pushed for changes in his state and has seen those changes occur recently:

The last two years, every region has now gone back to opening up where you can enter two teams. In fact, I want to say one region allows three entries at both the middle school and high school and, I think, that is because there might only be four schools in the region. So, it- it allows those smaller schools to spread their teams out and give multiple kids opportunities. But the last two or three years, regardless of whether you're on that A or the B team, if you win your event at regionals, you move on to the state competition. So, theoretically, I could take our team which has won- which has placed in the top four at regionals and then I could take a completely other team if every single kid in that won their event. So, theoretically, I could take 30 kids, but that would be- I don't know if that's ever happened because only one team per school is allowed to go to state and based
upon that scenario, we'd end up like first and second. So, it'd be that second-place team that would be out of luck, but I've taken - since this has started, we'll take our team of 15 and then four to six additional kids if they- if those off kids have won their events so that they qualify to go to State. So, you not only have the 60-the- the 32 teams per level at state, you potentially have another 23 pairs of students per region also in that. So, you can have- you'll have 32 teams entered in Meteorology at the B level at state and based upon this- the eight regions- you could have another eight entrants into that Meteorology if they won the event and they weren't on a team that made the state. So, it's- it's way past time to do that. I've lobbied for that. My buddy, who used to be the Regional Director here, we lobbied [the] state for probably 10 years to do that because we said, "It's so unfair that these kids win regionals, they've proven they're the best, and they don't get to go to state.

Scott talks about the importance of student folders. "When we get together in September, that's the very first thing we do. We have a shared Google drive with the rules in them and then we teach the middle school kids how to make their own folder in there." He explains that the rules are available free online, so his high school kids will often access them as soon as they are released in the summer and come to school with the rules in hand. "From that, they start developing the notes that they can take in. Some events like Astronomy or some of the ID events, you're allowed a three-ring binder that you can fill to your heart's content." Other events are a little more restricted, but he describes how his students creatively handle that. "In Meteorology, you're allowed one single sheet of notes to take in front and back. Some of my
upper-level kids are very, very advanced at developing their notes to the point where they take a magnifying glass."

## Workplace and community support.

Scott enjoys having connections with coaches from other schools. In response to the question about how much financial support a team needs, he shares information he knows about some financial situations with coaches not interviewed for this study. "If you are talking about a small school versus a large perpetual national competitor, it's the difference in the Grand Canyon." He has a friend who teaches at a small school and runs both a Middle school and a high school team on a shoestring. "Her Superintendent is fantastic. He's gone out of his way to try to give her an equal budget as he would for sports." He contrasts that with another friend at a similar sized school also running both middle and high school teams in the opposite situation. "She has to fundraise because the district either doesn't have the money or doesn't think it's important." Then he describes the situation at the school which always attends nationals from his state. It is a private school. "The kindergarten tuition there is like $\$ 12,000$ a year and it goes up to, I believe, $\$ 24,000$ your senior year. They have their own bus, so they can pretty much go where they want when they want." He explains why the ability to travel is important. "Once we got a dedicated budget, it opened up. It allowed us to go to more meets. I do feel sorry for the schools that are pretty decent at Science Olympiad and could be better if they had administrative support."

He references Anne's school as the example of the perpetual national champion with outstanding funding. "They have a required class that you meet in after school." He places them on par with Robert's school (State C Champions) as they are both church affiliated private schools with larger tuition price tags. "Those parents are already investing in this kid's going to
go and be a doctor/this kids' going to be a lawyer. So, they can go where they want when they want. They have their own bus."

Scott talks about the importance of coaches supporting other coaches even if they are from other schools:

We're, as far as I know, the only program that schools offer that literally go the whole school year. And we have schools that they'll practice for Regionals two weeks before and then they'll go to Regionals and that's it. And we've actually hooked up with some of those schools to be kind of mentor schools to say, "If you really want to be successful, lean on us. We've got the experience. We'll share tests with you." And we do that a lot - like old tests - and expand their program. But, yeah, some of my closest peers and friends outside of family and what have you are the Science teachers that have competed in Science Olympiad.

The support he received from other coaches when he was new was critical for him. "I owe those coaches tremendously." He says that after the fact one of them joked with him when he let her know his gratitude, "All you did was beat us, you know. If we'd have known that we wouldn't have helped you."

On the subject of stipends, Scott comments that his school is one of the most underpaid Science Olympiad coaches in their region. He bases this on his communications with the many coaches he has built relationships with over the years and gives a specific example. "The other coach that is with me now, she made twice what she makes now when she was at her other school." That other school is part of a large school district in the state. "In that region the Science Olympiad coaches are paid correspondingly like sports coaches." Scott says he gets $\$ 650$ for the whole year. "That's enough to buy a whole load of building supplies and supplies
for events, so we've always done that." In other words, he does not keep the stipend to compensate for his extra time. "Luckily, my family is in a situation where we're financially sound. Every bit of money that I made as a stipend went right back into the program."

He says that his team does have a dedicated budget for each of the two team divisions. Since the middle school and the high school often travel together, he says that early on he did some fancy budgeting to maximize the use of both budgets to the benefit of both teams. He says that getting a dedicated budget allowed the teams to go to more invitationals. "We do our best every year to use every last penny of it." He is allowed to carry over money from year to year for Science Olympiad and in this way, is not like the science department budget. "Our science departments are use it or lose it." He says that it was helpful to be able to accumulate money in the account especially after they started hosting their own invitational. The money they made in the early spring is enough to fund their travel to invitationals the next fall and that includes being able to afford out-of-state travel.

Scott states that he has employed some fancy budgeting and smart money management to build programs that have relatively steady funding from one year to the next. Running both the middle school and high school teams allows Scott to leverage both budgets to the advantage of both teams when they are doing combined activities. Scott has also found a way to get income. "We've taken that into our own hands by running our own meet and making money that way."

Generally, Scott only asks parents to bring snacks and drinks and not for monetary donations. He likes to try to lessen the burden put on a student's family for supplies as much as possible, but some families are willing to provide that support. "We have a lot of parents that will fund the building of a catapult or something because it's like being in $4-\mathrm{H}$ or on a competitive soccer team. It's the cost of entry."

In the past he was able to pull heavily from the nearby university, but he says that is less available to him now because those professors have left or their kids are no longer involved. "We had a dedicated list," he says. He could tell the student who to call and set up an appointment for help. He said that it started with professional parents but branched off into other experts hearing about it and agreeing to give an hour or two over the course of a month to help the kids out. He recognizes this is a benefit of a larger community with a university. However, he refers again to one of the coaches he knows from a smaller school in an agricultural town. "You know, an old farmer knows more tricks to keep equipment running than most engineers ever will, and they've had to band-aid stuff together because they can't afford new. Relying on that expertise is a huge benefit for small communities."

Scott also does not see a lot of help from the other teachers outside of the two science teachers who are also assistant coaches. "At the middle school there are a total of six Science teachers. At the high school, eight or nine I'd have to say." The three of them at the middle school run both teams. The high school teachers are not directly involved. "The kids can go see them if they have needs and issues and they have done that, but with the high school team, we pretty much keep it hands off." Scott does not teach at the high school, so the team must borrow a room from one of the teachers. There is a teacher at the high school that allows the high school team to use her room for the past seven or eight years. She has a cabinet where the tests from previous meets are deposited that the students can come in and access. Scott says, "She will let me know if she's not available for the kids to come work, but at most we might have one or two kids go in, get some old tests, get them copied, and then go on their way." In talking about help from non-science teachers, he only has the example of the librarian whose son is involved.
"She's kind of our team Mom," he says. "As far as just straight non-science teacher in the buildings that have gotten involved, uh, that's a pretty rare entity."

Scott thinks that a room where they did not feel like they were invading someone else's space would make the team better. He explains his ideal situation, "We'd have a dedicated room where the kids could meet and I would be there after school which I think is probably the next step to make us a top - consistent top three to five team at State."

Scott hesitated when commenting about emotional support. "Um, I was thinking I don't care, but then I got to thinking. My principal at the middle school, every year when we go to the state competition, we get to leave early." He explains how it is important to the kids to get to the site and scout out where their rooms are. "They've worked all year. They've worked hard. They deserve that early out to get down there and make them as comfortable as possible for state." He mentions another trip bonus, "Our principal every year buys us lunch to eat on the road as we head towards state, so I would consider that both emotional and financial." His comments are about support for the students and not himself. "Some of the kids, it's their first time away from home. So, we kind of have to play the parent or big brother and big sister role which is nice."

Scott says his state does not have a Facebook page for the coaches. He has a personal, private page that is set up for the high school. "We will allow parents in there and the students for transparency and we'll post a lot of resources there, but for the other schools, just emailing." He talks about how he has contact with a gentleman in Michigan who runs a very large test sharing platform. He sends his tests in exchange for access to the platform. "When you get over into Ohio and Michigan and Pennsylvania, those schools that do Science Olympiad there, they are the cream of the crop in the country." He feels that having access to the tests that they use in their pre-meets is beneficial to the team. He has a contact in [State C] that shares the tests from
[State C] and [State D] meets that her team attends. So, the contributions cover a wide range and give the students an opportunity to study a variety of questions over their topics. "So, a dedicated platform like a Facebook group - a cry on the shoulder group so to speak - no, but we all piggyback off of each other's emails based upon who is going to the meets and that email system."

There is some support from parents. Scott tells how over the years parents have driven to the state competition early in the day ahead of the team so that they could stake out the homeroom for the team. "Getting a home room at state is a pretty competitive item. They don't allow you to reserve them." He says he has had a parent volunteer to arrive there at 5:30 in the morning to get the homeroom for them. "That's good morale and emotional support there." He has some community support from one person who teaches at a nearby university and will always come and run and event at the school invitational. Scott had a parent some time back that went around the community asking for donations for the team and garnered a good amount of support. "He ended up getting a good enough donation where we could buy dedicated lab coats for our meet and his wife embroidered patches that said [School name] Science Olympiad." He says that he tries to not ask too much from the parents because he knows they are pulled in so many directions.

For local publicity Scott says that they send article to the newspaper. "Again, middle school kids love seeing their name in print or hearing it." He says that high school kids do not get as excited. They are like, "Yeah, that's kind of nice." When asked if he had good luck getting articles published in the local paper, Scott responds, "Yep, we've never not had them published." Not everything about publishing goes the way he wants it to, though. He tells a story about a reporter who came to do an article on their meet. "We tried focusing on the

Science Olympiad aspect and she wanted to focus on us. That's not why we do this. We do this meet for the kids. Please focus on that." They were disappointed that the story did not get published.

He says that the first thing he does on Sunday or early Monday after a meet is to type up where they went, how the team placed, and which students placed in their events. "We like getting the kids the recognition because they deserve it. If you place in a meet and you beat the likes of [recurring State A Champion] or [Anne's team] you should be noticed."

Some school clubs such as Scholar Bowl qualify for letter jackets at his school. "That one student I keep talking about, she is making a push to actually make Science Olympiad something they can varsity letter in." He indicates that would increase a feeling of school acknowledgement and recognition for the students.

Scott's answer to what other types of support are critical for a team to be successful is, "Money. Boil it down to one word, it's money. If you have the money, you can travel. If you have the money, you can buy the supplies and you don't have to rely on the parents." He explains the need to provide snacks for the kids. "Some of the kids we get, it's not that we're acting as a babysitter for them, but we know that they come from families that they just don't have much." He likes to be able to lessen the burden on what the family must provide to be in this extracurricular activity. He says that for the building events the school does supply the materials, or the kits needed. However, he has some parents who will pay the cost for the materials for their student. He says that they just view it as the cost of entry like being in 4-H or soccer. However, he feels that it is preferable to have a program that is well enough funded that parents do not have to contribute.

## Perceived Challenges of Science Olympiad Involvement <br> Personal and coaching challenges.

Scott talks about being at a disadvantage when he was coaching at a small school. "If I would have had a full team of 15 , I believe we could have competed well and probably gone to state in the third or fourth or fifth position. At the time, our regional took five teams." He identifies the main factors small schools must overcome in his experience. "The number of students and the time outlay are, I believe, the biggest factors that probably hinder the small districts."

Scott says he has personally experienced burnout. "In fact, a couple years ago, um, doing the same thing every year, we're successful, going it kind of got tiresome." He explains how a new person joining the coaching team helped. "Even though she was still essentially only three years into Science Olympiad, she came in with some great ideas. So that reinvigoration, um, helped me personally get over any burnout." He says that teaching burnout is also a factor in addition to coaching burnout. "I've always kind of told myself I don't do Science Olympiads so I can teach, I teach so I can do Science Olympiad. And it's kind of both ways, but it's the Science Olympiad that helps keep me going." He says that he knows of some districts that require a rotating coaching pool to give the coaches a break, but it is not that common. "I think commonality is what has tightened our friendship with a lot of our peer coaches. They're in it because they love it and it's what they want to do. So, they fight through." He thinks he would have fought through the burnout without the new person coming in, but he was glad to have the support to make it easier. "I think the number that burn out is probably very small if they are in it with their whole heart and from what I've seen, the vast majority of coaches are in it because it's in their heart." He cites the desire to give kids the experiences of the 23 different events of their choosing and an opportunity to find that they can do well in STEM is what motivates most
coaches and keeps them going. "So, I don't know if that's unique. Um, I kind of think it is. I like kind of like to think the whole Science Olympiad program is a unique aspect of the educational career."

## Perceived student challenges to participation.

At the first of the year Scott says that all the students want to do what he calls "the glamorous events". He names Crime Busters, Bridge, events dealing with planes, and just building events in general as these popular ones. Crime Busters is a Division B event where teams of two use given evidence and run chemical tests to solve a fictional crime scene (Science Olympiad wiki Crime Busters). Teams in the Bridge event build a lightweight bridge meeting specific construction parameter which is capable of holding a designated weight for maximum efficiency. Students must keep a Design Log which must be submitted along with their bridge at the time of competition (Science Olympiad wiki Bridge). There are several events that deal with planes or flight, and they rotate in and out of SO depending on the year. He likes to let the students choose the events they want to compete in, but he always must challenge some students to consider some of the unpopular events so that the team has them covered. The coaches all tell them, "The more versatile you make yourself to use, the more valuable you are to us." He tells them that it is a great goal to want to win state in one event, but the team needs members that can be competitive in multiple events.

Time is the major cost for student participation. "The vast majority of the time for those that are successful is spent outside of our time together," explains Scott. "Especially at the high school level since we meet so rarely. At critical points coming up to meets we will make ourselves available, but the majority of the time to do this is done outside of school." He says that for the high school students "it will take them dozens and dozens of hours to develop the notes that they can take in and fine-tune them."

He typically sees the middle school students copy and paste a bunch of stuff and then after the $1^{\text {st }}$ tournament realize that they are not good. "We'll help them parse that out to a more reasonable level." Overall, he says that middle school students will probably have their motes for regionals done in a couple of weeks, but to do it right takes more time than that. "To get your notes right, it takes multiple meets and multiple weeks to get the notes fine-tuned to the information that you think is important."

In his opinion build events do not take more time than testing events, "If you really want to do your best and end up winning state, then the test events can take a little bit more time," he says. "The thing about the build events is you have to build multiple copies and you test it and you analyze where it broke. And that takes multiple tests and running multiple graphs in Excel and analyzing small changes." However, he explains that the student who spends the time to properly developing their notes for the testing events can spend as much time or more than they do on the building event. He points out that the building events use up materials and so the time and effort is more visible.

As far as the hours involved, Scott says, "Well, if we meet at the middle school twice a week, that's an hour right there and, if you're doing a tester build, we ask that they spend at least twice that amount outside to do well." He says it usually takes them not doing so well at the first meet to realize "Wow! I need to put in more time." He estimates that from September to November or December when the first meet occurs, the kids are putting in about two to ten hours a week. After the first meet, the kids that are serious and dedicated understand what it takes and will increase their preparation time from 10 to 20 hours a week. "They may have a build party at one of the person's house on Saturday and spend eight hours working on their mousetrap vehicle or their bridge and then they might not touch it until the following weekend." Most students are
competing in multiple events, so his statement implies that during the week they are spending time studying for their non-build events. He says that after the first meet the serious students will increase to about 20 hours per week.

Scott points out a minor problem with having several invitational meets, "With Science Olympiad we run into such varied differences in the same event at different meets." This is because different people may be running the event from one meet to the other and have a different interpretation of the rules and a different focus on the material. This means the students have to rely on their notes and they must have very thorough notes. When a coach takes a team to a meet, the coach is expected to run an event. Scott says he tries to run the same event at every meet he attends. This means that students will encounter a more consistent interpretation of the rules for that event, but it creates a problem for him. "Okay, the kids have seen my test for Water Quality. They have a copy of it. I have to do a completely new test." He says that he tries to take both the middle school and high school to five pre-meets before regionals.
"We had to make a couple of tough decisions for the Regional team over the last couple of years," says Scott, "but we've always said - and we tell the kids this pretty much from the getgo - the harder our decision is for the Regional team, the better the team's going to be." And while he and his colleagues do not particularly relish the hard decisions of which students to take over the others, they tell the students from the beginning, "You've got to make yourself valuable in multiple events and prove yourself. This is a club. We're allowed to make cuts just like middle school sports or quite often high school sports."

On the individual level Scott has seen some kids not do well at the competition and not want to continue because they said they did not enjoy it. Other students come back with the desire to improve.
"And it usually takes them getting their tails kicked at their first meet to realize they need to put in more time." Scott explains that from September to the first meet his kids are putting in 2-10 hours per week. Sometimes a large chunk of that time may be a full day on the weekend at a build party at someone's house.

One part of a student being competitive is having the ability to choose good partners. He says that if a student chooses a good partner, then they do not have to work as hard because the work is going to be evenly distributed and they will generally do better as a team.

Scott sees kids leave the team because they just did not enjoy going to events. He says that sometimes the coach just must pick them up and boost their ego a little. Sometimes all it takes if for him or another coach to look at what they did and say, "Well, you got this section right, so you're not that far off from doing well."
"One of the best and brightest kids we had as a sixth grader was in the gifted program," says Scott. "His parents' expectations were so high that he had to win." Scott describes how after taking second place to the same team at two different tournaments, he was struggling with the situation. "I think that was probably one of the best things that could have happened to him. It took his partner in the event to tell him that it wasn't that they weren't good enough, it was just that the other team knew the material a little better and that they could either get better or not." In the end, Scott says they placed at State in their event which he thought was a huge accomplishment.

## Advice to Those Coaching Science Olympiad

Starting a Science Olympiad team requires some type of funding for the initial expenses. Scott tells an interesting story about his building of his program and the difficulties involved. He describes how the jealously that other schools have towards his program is somewhat frustrating
because he does not think they understand the struggles he went through to get his team to where it is today and to maintain.

In addition to travel there are other costs for a team to compete. Scott breaks it down in detail. For his state, the fee is $\$ 147$ per team. "So, this year at the middle school level, we paid $\$ 294$ for one complete team of 15 and then for another 6 to compete on our B team." Then he did the same thing to have one complete team and a partial second team at the High school level. "That second team can be cost prohibitive to schools that don't have a lot of money, but we're going to take advantage of that because we want to give those kids the experience."

Scott warns others thinking about coaching at a small school about the disadvantages he faced when he was coaching at a small school. "If I would have had a full team of 15 , I believe we could have competed well and probably gone to State in the third or fourth or fifth position. At the time, our regional took five teams." He identifies the main factors small schools must overcome in his experience. "The number of students and the time outlay are, I believe, the biggest factors that probably hinder the small districts."

## Appendix R: Sophia's Science Olympiad Experiences

## Introduction

Sophia is a homeschooler and not a professional teacher. She has earned a PhD in epidemiology and beyond teaching her own children she has mentored other homeschoolers in subjects such as AP Environmental Science. Since her team consists of homeschool students, there are no school demographics to report. She states that there is not a home school association that serves her area. There is a volunteer email list of people who homeschool in the five-county area of the city, but not an organization to which homeschoolers belong. However, her team is limited to only two of those counties by national Science Olympiad rules.

## History of involvement in Science Olympiad.

Sophia got involved in coaching a Science Olympiad team because the coach for her son's team stopped coaching when his son graduated. "No one taught me anything about being a coach," she says. "The annual coaches' clinic in Phoenix was a great help, but it was quite a few years before we had the funds to send anyone." (The clinic she is referring to is the Summer Institute sponsored by Science Olympiad every summer in Arizona.) The team is recruited from homeschool students living in a two-county area in State D . The team is a general science team and competes in other science related competitions such as Science Bowl and Prometheus Bowl.

## Perceived Benefits of Science Olympiad Involvement Personal benefits.

Sophia does not give a lot of personal benefits for coaching Science Olympiad. She says several times that she really enjoys working with the students. As a parent she sees a major benefit in information exchange. The nature of being homeschoolers means that the parents are very involved in their student's education but may be working in isolation. When parents bring their students to practices, it gives them an opportunity to meet other parents and exchange
information. Sophia finds this especially helpful in the college application process. "We had parents who had been through it before and we could all exchange information about what worked and what didn't because we're in a kind of unique situation as homeschoolers." She has been coaching this team for about 15 years and her youngest will graduate next year. Sophia would encourage anyone interested in coaching a team to do it because, "it's a great thing. It's been a great experience for my family."

When asked what she defines as success, she responded, "Success is students discovering new areas of science that they enjoy, building friendships, pushing themselves academically and working successfully with partners." For her as a coach, she says, "Success is making sure the students have a positive experience and, very importantly, making sure that someone has the necessary tools to take over when I retire after this year."

## Perceived student benefits.

One of the benefits that Sophia's team offers to the homeschool students in her area is that she takes everyone who is interested in competing onto the team. There are no requirements for admission. "We just ask that students be dedicated enough to participate." Sophia says that even though her students are all homeschoolers they do a number of activities. "They don't just sit at home." However, she feels that the science team offers them a lot of opportunities for team building and networking. A lot of the same kids are on the math team, so that and science team activities are where they build their community. They do their competitions together and they meet the other students who will be doing AP classes with them.

Sophia believes that Science Olympiad participation does impact content knowledge for homeschoolers. She thinks this is especially for middle school because the focus is not as much on college prep yet and there are not as many boxes that have to be checked as a high school level student has in trying to satisfy college entry requirements. This means that a great deal of
middle school curriculum is very open and up to whatever the parent decides. Science Olympiad can provide some structure for what they are going to study. Sophia uses the Food Science event as an example topic choice for Science Olympiad. If the student is going to compete in that area, then their science that year will be everything involved with food science. Sophia says, "There's a lot of different things you can do related to that." As an example, the topic for the 2021-2022 competition year was candy making. The test portion of the event focused on food chemistry and sugars. The laboratory portion of the competition required participants to determine the sugar concentration of solutions (Science Olympiad wiki Food Science). In previous years the event focus was fermentation.

Sophia sees this in-depth focus into particular topic areas helping students create career interests. She says that a lot of her students have done really well in the Anatomy and Physiology (short descriptions of Division B events are given in Appendix T and Division C events are in Appendix U) event and some are now studying to go to medical school. "They dug so deeply into those content areas that now, when they're off at college, they're finding their anatomy and physiology classes really pretty straight forward." She says there is a student who probably would not have considered meteorology for a profession and is now in school to become a meteorologist. Sophia is referring to the Meteorology event where students demonstrate an understanding of basic meteorological principles and show the ability to interpret and analyze meteorological data on a written test. The main topic rotates each year between Climate, Everyday Weather, and Severe Storms (Science Olympiad wiki Meteorology). "A lot of the high school students take classes at the community college and a lot of them have chosen classes based on what they've done for Science Olympiad." She also has had students discover new areas of interest through Science Olympiad. "When they step into another event because
it's not filled, they find things that they really like." When they do not get what they want due to schedule conflicts, they get some material outside their comfort zone.

Over the years she has seen some students who joined the team for social reasons. She says that sometimes they and their parents were not well versed in science, but as they worked together on the events "it really created a love of science". She gives another example of a family of musicians and how the event Sounds of Music really brought the two areas of science and music together for them. In the Sounds of Music event the team of two builds an instrument on which they can play a scale. The team then demonstrates their knowledge about the physics of sound by answering questions on a written test (Science Olympiad wiki Sounds of Music).

Sophia says that her students like the competition. She is very careful to call her group a team to convey the competitive nature of what they do over just the social interaction people expect with a club. However, she likes to encourage the social aspect too. Pre-Covid they did a variety of things. "We have the kids plan parties and get-togethers and usually after the meetings they play soccer outside in the field." The high school team also elects officers and mostly run their own team. "It's a chance for them to get experience working on committees and negotiating with each other and organizing things like that." Sophia says that at the meetings they will have the students make presentations or will have a guest speaker. These speakers can include anyone that they hear about who is doing something interesting. "Very often those presentations are not related to a Science Olympiad topic." The university nearby has a "Present your PhD " program. "They'll send graduate students in to meet our students and do a presentation." She thinks it is just great exposure for the students to hear about the things. She tries to at least once a year have a speaker from the community college to come and talk about how to do dual enrollment so the students know about those opportunities.

The inference that Sophia gives is that nearly all her students are planning on attending college. She mentions how being on a competitive team is good for their college applications and how she writes a lot of college recommendations. In addition to the benefits of college prep, Sophia mentions some of the other types of skills that students learn. The students must learn time management skills. Especially, those attending community college must balance schoolwork and exams with competitions. Students also must learn communication skills. Students need to communicate issues they are having with their partners both to the partner and the coach. If a student needs help, they must learn to ask for that. Sophia says there are all different skill levels on the team, but that creates opportunities for some students to develop leadership and mentoring skills. "We have a lot of older students who help and tutor the younger students." She explains that it is important that a student learns how to study.

A final positive benefit for students that Sophia sees is that "for the most part, everybody at some point during the year medals and it's just so encouraging." She explains how even if the team ranks in the bottom half of the pack, but one student wins an individual medal, it gives the whole team hope. It helps to keep the team motivated because students say, "Oh, we can do one more next time."

## Workplace and community support.

Sophia basically has two needs for support. She needs event mentoring and financial support. She has two sources for these: parents and the broader community. The trip to nationals previously mentioned presented some real problems for her team in just handling travel costs. "We had people who wanted to donate but weren't able to do that because we weren't a non-profit." The parents of the team members found they had to create their own non-profit because not only could they not accept donations, but unlike a school, they also did not have insurance. Being a non-profit also allows them to apply for some grants.

Once able to accept donations, Sophia found a bit of support in her community. A small foundation gave them a grant to buy a laser cutter. Some local restaurants and food manufacturers, a popsicle company, and a salad dressing company all donated money to help cover their insurance. Trader Joe's and a local grocery store donated some money to help them when they went to nationals.

The parent support was really important for all of this. "We have some pretty persistent parents who will go out there and knock on doors and get donations." Because they are not a school, they do not have a bus for transport to tournaments. "When we have out of town events, all of our families have to get there on their own and pay for their own hotel room." Also, each family has to pay for related materials that the student may need for builds. If the non-profit has enough money, they will dole out some to help cover materials for expenses.

With coaching and mentoring help, Sophia usually has a parent who helps with middle school and another one who helps with high school while she oversees the big picture. Again, because it is homeschool, the parents are the first choice for mentors. "A lot of our parents have zero background in science, but we found that really does not matter." Especially at the middle school level, the students mostly need help in how to study and organize their notes. She explains that as long as a parent can help the student organize, that is adequate and they do not need to be a subject matter expert. However, Sophia says that most of her parents are really well educated and some are educated in science fields. She has had a professor of biomedical engineering, a former physics teacher, and someone who used to do experimental design professionally all lend their expertise over the years.

A professor from the nearby university has helped with Rocks and Minerals and for a while they had someone who would give feedback on some of the builds. She says this type of
help is infrequent. "It's usually just parents and older student who have been there and done that who reach out to the newer students and share resources." Recently, she has had a parent volunteer to set up a website and do a lot of outreach to try to recruit new team members.

## Perceived Challenges of Science Olympiad Involvement <br> Personal and coaching challenges.

Time is the only thing that Sophia considers a personal drawback. Pre-Covid she had more time to spend with non-profit issues, writing recommendation letters, as well as trying to mentor. "It takes a lot of hours to coach the science team." With Covid she has had even less time. "I'm a PhD epidemiologist, so I went back to work with Covid unexpectedly." Working fulltime now, she has less time to help with the team and to work for the team's future.

She says that one of her biggest problems as a coach has been with parents not always agreeing on how the team should be managed. Also, she says, "Not all gave students the support they required (i.e., help scheduling meeting with partners, getting materials, rides to see partners)." Another challenge she names is with student who are not interested in being on the team but who are pushed to be participate by their parents.

## Perceived student challenges to participation.

Sophia only sees time as a personal drawback for students. "The high school kids are all juggling college schedules because they almost universally are taking probably close to 12 credit hours at the community college." She says that this makes it really hard for the juniors and seniors to find time for Science Olympiad. However, she thinks this is probably comparable to regular school students with AP classes.

Beyond time as a personal drawback. Sophia sees some general drawbacks about Science Olympiad in homeschooling that affect the students. A major issue to homeschooling is that there is no school building for them to have their meeting in, store materials, or test their
builds. Most of the builds require some space for testing and the flight ones require a high ceiling. Since a lot of the testing and re-testing is occurring during winter, outdoors is not always an option. The non-profit does rent a rec center for meeting, but its use has been restricted during Covid. Therefore, most recently meetings have been online. The rec center does have a rental fee. The members of the team pay dues of about $\$ 100$ per year to help cover the rental expense.

The membership dues and other expenses can be a hardship on the family. As previously mentioned, the family is responsible for the cost of study materials and build materials that the student needs. The non-profit tries to help with material expenses, but since Covid they have not had a lot of donations. Also, there are the previously mentioned travel and hotel expenses that the parents must cover.

Sophia prefers to think that the students have challenges to overcome rather than there being any actual drawbacks to Science Olympiad participation. "I think a lot of these kids are used to getting what they want, so when they don't get the events or the partnerships that they want, sometimes that can be a bit of a problem." She says that sometimes multiple students want the same events. Sometimes the events they want conflict with each other when the tournament schedule comes out. This has been more difficult with the virtual format than before. She finds it is easier to manage the student expectations when she has everybody together in person because she can remind them, "Yeah, I know you've been studying for these four events all year, but you have to be prepared that on the final schedule these events might conflict and you might not be able to do both of them." She says the students have to learn to deal with that kind of disappointment and frustration, but she implies that she views this as a growth opportunity. This
is not just because they learn to deal with disappointment, but as previously mentioned they have to pick up a new category and learn something outside of their comfort zone.

Additionally, if a student is having problems with a partner not doing their part, they have to make decisions on how they will handle it. Do they want to mention the issue to the coach so that the partner's parent can be contacted or do they decide to mostly do the event on their own? Sophia thinks it is a good people skill challenge.

As a homeschool team, parent support is even more critical. "If a student doesn't have parent support, it won't work for them to be on the team." One reason for this is that except for juniors and seniors, students are not driving, so parents must transport them to and from meetings and tournaments. Sophia says that Science Olympiad meetings aren't drop-off events. "We expect the parents to be there during the meetings." This is so that parents get the information they need about upcoming events as well as being on hand to help with crowd control. Additionally, Sophia is open to younger siblings coming to the meetings if the parents are there to supervise because the younger ones see what the older ones are doing and become interested in possibly doing it themselves when they are old enough to join a team.

There are some changes that Sophia sees happening in home schooling that may affect their ability to have a team. Some of the issues start with Science Olympiad rules. "Not everybody who homeschools meets the eligibility criteria for Science Olympiad." This is more than just the two-county rule. Sophia says there are a lot of other restrictions by Science Olympiad. She agrees that some are necessary but thinks that some are inappropriate because home schooling in every state is different. One of the preclusions is that a homeschooler cannot be doing any kind of online school. This causes an issue because Sophia says, "more and more parents are plugging their kids into pay for activities rather than actually participating themselves
as being teachers themselves." Sofia says they turn these students away in order to meet SO requirements. These purchased activities or curriculum are not a single virtual academy or school and different activities may be purchased from different providers, but because they may offer live classes, counseling, and/or tutoring for those specific activities they can blur the lines between what is online curriculum and what is an online school. Also, each state has different rules about homeschooling and that adds to the confusion at the national level because what one state may allow as a "legitimate" homeschooler may be broader than what Science Olympiad is allowing. Therefore, it is somewhat unclear if participation in some of the online curriculum programs could result in disqualification of the student or team as homeschooled. (The national policy for qualifying a Science Olympiad team can be found in Appendix H.) As use of these online activities increases, she is concerned about what that means for the future of the team and that participation in these things will reduce the pool of eligible students for recruiting to the team as well as make it impossible for students using this type of curriculum to experience the benefits of being on a team.

Another obstacle in the national rules is the previously mentioned two-county rule on homeschoolers. The rule is that students must come from two contiguous counties. Her metropolitan area covers five counties. She says she has students who do other homeschool activities together but cannot be on the same Science Olympiad team. "We have people who are in the smaller of the five counties who have no option for doing Science Olympiad because of that two-county rule." She explains that there was a parent who started a team in one of the other countries for a couple of years, but when her children graduated, she could not get any parents to take over leadership of the team. She says it is heartbreaking for her to get inquiries from homeschoolers in those counties. She points out that the rule does not apply to public or private
schools. "In fact, we have schools that compete in our state competition who are actually boarding schools and they have students from all over the world." Private schools in her own metro area (as well as some in other states included in this study) can pull their student population from more than two counties without penalty to their team.

## General challenges.

The challenges that Sophia sees for the team overall are things that cause her concern about the team's future. She is planning to hand off the coaching duties when her son graduates. She acknowledges that it is a problem like what every school faces when a long-time coach leaves. Will the next coach be able to keep the program going? The two areas that she sees her successor having to overcome are difficulty with recruitment and the previously discussed national Science Olympiad rules that she feels unfairly target homeschoolers. During Covid it has been hard to recruit new families and bring them on board virtually. Previously, they had rented a space at a recreation center where they could meet but they were not allowed to meet indoors there during Covid. They have recently started meeting in the park areas outside the recreation center. One hardship Sophia has faced with recruiting is just getting the word out to other homeschoolers because there is not a central organization through which to contact everyone.

To enable the team to survive after she leaves and to make document access easier for everyone, the non-profit group uses Google for Nonprofits. They have tried to scan all their documents so that no one has to physically house or transport them. "We used to have a big rolling cart that probably weighed over 100 pounds that had binders for every event." Sophia says they have been diligent in documenting everything they do, and they have all that history of binders, practice tests, student preference forms, and other documents they have developed now saved in their Google drive. "We've worked really hard to build institutional knowledge so that
the team can carry on whenever people move off the team." It is extremely obvious that this is a great concern to her. She has been the person driving the team for 15 years while other people have come and gone. She feels the key is to recruit enough people with younger children so that the parents will invest in Science Olympiad long term and not just for a few years while one student is in high school.

She says that they have formed a board of directors for the nonprofit and she has just stepped off that so she can see that is continuing well without her. The current high school coach has a son who is a few years from graduating. "So, hopefully, she's getting experience now and will stay on for a while." The middle school coach also has a fourth grader, so potentially she will be involved for several years. "We just have to hope that people don't move." She thinks this is like the problems faced by regular schools. "But that really is an issue and we've watched as other schools [names a school in her state] that used to perform really well and as soon as their coach left them the team pretty much ceased to exist."

Another thing she would like to see is for schools to have to compete in their own regional tournament for state qualification. There are a lot of super competitive teams in the two larger cities in her state. "And some of them come specifically to our regional because they think that they can get into state by doing that." Unfortunately, it is more than just think. She says that the strategy does usually work for those schools.

## Advice to Those Coaching Science Olympiad

The first advice that Sophia gives to anyone wishing to start a homeschool team is to be aware of the time it will take. Beyond personal time, it will also take time to build the team. It takes time to acquire test banks for study and to know what information to pass on to the students. She says that the team also has to reach a critical mass. By this she means that a team needs at least nine or ten students to get started and it is ideal to have the full 15. "You really
need that critical mass to kind of keep going and have enough students because you want them to be partnered with someone." Sophia feels that partnering is a big part of the experience for the students, so coaches need to try to partner students as much as possible.

Sophia says that a coach needs to be strategic about what events they put students in and which regionals they attend. Although, as she has stated, she does not like the practice of choosing to attend a regional tournament other than the one in your own region, if it is allowed by the rules, it is part of the strategy for getting a team to state. Her state has what are called state events. These are events beyond the 23 nationally selected events. Sophia could not recall the names of the five events in the interview but said that they are usually events that the nationals has out as trial events. These are events that are being piloted in a few states for feedback in consideration for future use (Science Olympiad website Trial Events). Further down on the same page is a list of events that can be used for open house or to give extra events at competitions. These events are not trial events. At competitions in her state, teams can choose which 23 events they want out of 28 offered and they all count equally for scoring. If a coach is in a state that has these state events, then it becomes a game of choosing which events you think your students will score the best in over other teams. "So, if very few teams enter a certain event because the students are not fond of it, then you focus on training some students for that event and drop another event. In Sophia's state at the regional and state tournaments, they get to drop five events. This means that they can pick up state events and drop national events. She says there is a lot of strategy in doing that "because teams that regularly go on to nationals often will not focus on doing state events and so we can really up our ranking by doing state events."

When asked if focusing on state events would hurt the team's competitiveness at the national tournament, Sophia responds, "Well, we know in [State D] that it's unlikely that we will
go to nationals." She says that the middle school team did get to go about five years ago. "That was a terrific experience." Her state has two berths meaning it can send two teams to the national tournament. Her focus is just to rank high under the top three teams that are usually fighting it out to go to nationals. Her high school team has placed in the top 10 in the state every state tournament held in the past five years, so this strategy is working for her to do well in state.

To start, a coach may not be able to be strategic. "In the beginning, we just filled the events that we could and that students were interested in." Over the years she says they have evolved to try to cover the events and be strategic. An important thing in the first year is to not necessarily win a tournament, but to try to get students to a level where they can get a medal in one event at an invitational sometime during the year. Sophia says she once asked a state director how he had kept a high school team going in the past. She says his response was, "Winning really helps." Each individual win is a motivator for the whole team.

For advice on how to recruit the team, Sophia holds an open house every spring at the rec center. She has students demonstrate their builds and they put some sample tests out for students to see. She also tries to get a speaker from the community college to give a talk about how to dual enroll (sometimes referred to as concurrent enrollment). She thinks that has been a good practice because of the type of student it attracts to the open house. "That's a pretty academically minded student." Therefore, a student may come to the open house just to learn about concurrent enrollment at the local community college and have never heard of Science Olympiad, but after learning about it, decide to give it a try. Because of the level of parent involvement required in a homeschool team, Sophia has found that word of mouth is the most successful way to recruit because parents need to understand the commitment involved. "The
best way to get people who understand that is if they know someone who's already been on the team."

Her last piece of advice that she really stresses concerns the two-county rule. "I would really encourage homeschoolers to get together and fight the two-county rule. It makes it really hard for us to have sustainable teams and that may ultimately be the demise of our team."

## Appendix T: Short Description for Division B Events

## Short descriptions for Division B events

(Descriptions are taken from SciOly wiki)

## Anatomy and Physiology

Participants will be assessed on their understanding of the anatomy and physiology for the human Respiratory, Digestive, and Immune systems.

## Bio Process Lab

This event is a lab-oriented competition involving the fundamental science processes of a middle school life science/biology lab program.

## Bridge

Teams will design and build a Bridge (Structure) meeting requirement specified in these rules to achieve the highest structural efficiency.

## Can't Judge a Powder

Students will test and characterize one pure substance and then, based only on data they collect, answer a series of questions about that substance. Students will not be asked to identify the substance. Emphasis of this event is on the quality of data collected, answering questions about the substance and providing data to support their answers.

## Codebusters

Teams will cryptanalyze and decode encrypted messages using cryptanalysis techniques for historical and modern advanced ciphers.

## Crave The Wave

In this event competitors must demonstrate knowledge and process skills needed to solve problems and answer questions regarding all types of waves and wave motion.

## Crime Busters

Given a scenario, a collection of evidence, and possible suspects, students will perform a series of tests that along with other evidence will be used to solve a crime.

## Disease Detectives

Participants will use investigative skills in the scientific study of disease, injury, health and disability in populations or groups of people.

## Dynamic Planet

In this event, students will use process skills to complete tasks related to Earth's fresh waters.

## Experimental Design

This event will determine a participant's ability to design, conduct and report the findings of an experiment entirely on-site.

## Fast Facts

Teams will fill in a grid of terms that begin with a given letter to match given science categories.

## Flight

Prior to the tournament, teams will design, construct and test free flight rubber-powered aircraft to achieve maximum time aloft.

## Forestry

Participants will be assessed on their knowledge of trees found in the United States that are on the Official Science Olympiad National Tree List.

## Green Generation

Students will demonstrate an understanding of general ecological principles, the history and consequences of human impact on our environment, solutions to reversing trends and sustainability concepts.

## Herpetology

This event tests knowledge over amphibians and reptiles. Teams are presented with numbered specimen and asked to answer several questions about each of the numbered specimens' life history, distribution, etc. within the time limit for each specimen.

## Keep the Heat

This is a Division B event (known as Thermodynamics in Division C) in which teams design and build a device to insulate a beaker of hot water, and take a test on concepts of thermodynamics.

## Meteorology

Participants will use scientific process skills as well as qualitative and quantitative analyses to demonstrate an understanding of the factors that influence Everyday Weather.

## Road Scholar

Participants will answer interpretive questions that may use one or more state highway maps, USGS topographic maps, Internet-generated maps, a road atlas or satellite/aerial images.

## Rocks and Minerals

Teams will demonstrate their knowledge of rocks and minerals.

## Roller Coaster

Prior to the competition, teams design, build, and test a Roller Coaster track to guide a ball/sphere that uses gravitational potential energy as its sole means of propulsion to travel as close as possible to a Target Time.

## Solar System

Participants will demonstrate an understanding and knowledge of habitability within and beyond the Solar System.

## Sounds of Music

Teams must construct and tune one device prior to the tournament based on a one-octave 12-tone equal tempered scale and complete a written test on the physics of sound and music concepts.

## Storm the Castle

Prior to the competition, teams will design, construct and calibrate a single device capable of launching projectiles onto a target and collect data regarding device parameters and performance.

## Write It Do It

One student will write a description of an object and how to build it, and then the other student will attempt to construct the object from this description.

## Appendix U: Short Description for Division C Events

## Short descriptions for Division C events

(Descriptions are taken from SciOly wiki)

## Anatomy and Physiology

Participants will be assessed on their understanding of the anatomy and physiology for the human Respiratory, Digestive, and Immune systems.

## Astronomy

Teams will demonstrate an understanding of Stellar Evolution \& Variability.

## Bridge

Teams will design and build a Bridge (Structure) meeting requirement specified in these rules to achieve the highest structural efficiency.

## Cell Biology

This event integrates content knowledge and process skills in the areas of cell biology and cellular biochemistry.

## Chem Lab

Teams will complete one or more tasks and answer a series of questions involving the science processes of chemistry focused in the areas of Oxidation/Reduction and Periodicity.

## Codebusters

Teams will cryptanalyze and decode encrypted messages using cryptanalysis techniques for historical and modern advanced ciphers.

## Detector Building

Teams will build a durable Mass/Force Sensing Device that will accurately measure and display both voltage and actual masses of different solid samples ranging from 20 to 1,000 grams.

## Disease Detectives

Students will use investigative skills in the scientific study of disease, injury, health and disability in populations or groups of people.

## Dynamic Planet

Students will use process skills to complete tasks related to Earth's fresh waters.

## Environmental Chemistry

This event will focus on fresh water (e.g., residential, industrial or natural), the identified pages of The Clean Water Act (1972 \& 1977), wastewater operator's certification manual (Indiana March 2018 revision) and its applications, various testing of particular analytes using standardized curves (either interpreted or created), and stabilization ponds, \& introduction to the National Pretreatment Program.

## Experimental Design

This event will determine a participant's ability to design, conduct and report the findings of an experiment entirely on-site.

## Fermi Questions

Teams provide answers to a series of "Fermi Questions"; science related questions that seek fast, rough estimates of a quantity, which is either difficult or impossible to measure directly.

## Flight

Prior to the tournament, teams will design, construct and test free flight rubber-powered aircraft to achieve maximum time aloft.

## Forensics

Given a scenario and some possible suspects, students will perform a series of tests. These tests, along with other evidence or test results, will be used to solve a crime.

## Forestry

## Event Description Coming Soon!

## Green Generation

Students will demonstrate an understanding of general ecological principles, the history and consequences of human impact on our environment, solutions to reversing trends and sustainability concepts.

## Herpetology

This event tests knowledge over amphibians and reptiles. Teams are presented with numbered specimen and asked to answer several questions about each of the numbered specimens' life history, distribution, etc. within the time limit for each specimen.

## It's About Time

Teams will answer questions related to time and they may construct and bring one non-electrical device that triggers a single signal to occur three times at equally spaced time intervals.

## Ping Pong Parachute

Prior to the tournament, teams will design, build and bring up to three bottle rockets to the tournament to launch a ping pong ball attached to a parachute to stay aloft for the greatest amount of time.

## Remote Sensing

Participants will use remote sensing imagery, data, and computational process skills to complete tasks related to climate change processes in the Earth system.

## Rocks and Minerals

Teams will demonstrate their knowledge of rocks and minerals.

## Scrambler

Teams design, build, and test a mechanical device, which uses the energy from a falling mass to transport an egg along a straight track as quickly as possible and stop as close to the center of a Terminal Barrier (TB) without breaking the egg.

## Thermodynamics

Thermodynamics is a Division C (known as Keep the Heat in Division B) event in which teams design and build a device to insulate a beaker of hot water, and take a test on concepts of thermodynamics.

## Trajectory

Prior to the competition, teams will design, construct and calibrate a single device capable of launching projectiles onto a target and collect data regarding device parameters and performance.

## Water Quality

This is a former Division C event which tested students' ability to identify marine coral reef indicator organisms and their knowledge on indicators affecting estuarine and marine water quality.

## Wifi Lab

Teams must construct an antenna device prior to the tournament that is designed to transmit a signal at 2.4 GHz and complete a written test on the principles of electromagnetic wave propagation.

## Wright Stuff

Prior to the competition teams design, construct and test free flight rubber-powered monoplanes to achieve maximum time aloft.

## Write It Do It

One student will write a description of an object and how to build it, and then the other student will attempt to construct the object from the description.

## Appendix V: Science Olympiad National Policy-Team Qualification and Home Schools

This policy provides guidelines that are to be used with all schooling options and in all states. Primary enrollment at a school will be determined by what school holds the student's records and matriculates the student (a general definition of primary enrollment), and a student may only be primarily enrolled at a single school.

## A Team Endeavor

Science Olympiad requires all participants in Science Olympiad competitions to participate as members of a team, not as individuals.

## Public School Students

Public school students may participate in Science Olympiad only as members of a team that is formed in the local public school that they attend. In the case of $9^{\text {th }}$ graders, public school students may compete on the team from the middle school that they most recently attended. Public school students may not opt to participate on another school's team.

## Private, Charter and Alternative School Students

Private schools, "governor" schools, charter schools, and any other school that is qualified by the state and is housed in a single geographic location, may form Science Olympiad teams from among the students in their student body, regardless of where that student's home of origin is located. Such schools may not solicit or enlist public school or home-schooled students on their teams.

## Cyber or Virtual School (online) Students

## Option 1 - Participation through a Local Public School

If the state in which a cyber/virtual school student resides allows cyber/virtual school students to participate in local public school activities, cyber/virtual school students may either (1) choose to participate as a member of the Science Olympiad team at the local public school they would attend were they not enrolled in the cyber/virtual school, or (2) form a cyber/virtual school team from among the students in that school's student body as if they were students in a private/charter school as set forth above. A student may only participate on a single team.

## Option 2 - Participation solely through a State-Recognized Cyber or Virtual School

 If the state in which a cyber/virtual school student resides recognizes and financially supports cyber/virtual schools, Science Olympiad will also recognize cyber/virtual school teams consisting only of students who are enrolled at that cyber/virtual school. Such schools may not solicit or enlist public school, private school or home-schooled students on their teams.
## Home-Schooled Students

## Option 1 - Participation through a Local Public School

If the state in which a home schooled student resides allows home schooled students to participate in public school activities, home schooled students may either (1) choose to participate as a member of the Science Olympiad team at the local public school they would attend were they not home schooled, or (2) form a home school team as set forth in Option \#2, below.

## Option 2 - Participation through a Home School Team

Science Olympiad will recognize Home School Teams consisting only of students who live within the boundaries of two contiguous (side-by-side) geographic counties in a single state. As of July 20, 2011, the two-contiguous-county/single state policy will apply to all Science Olympiad Home School Teams who wish to attend to the Science Olympiad National Tournament and Science Olympiad will no longer qualify multi-county or multi-state Home School Teams. (This home school portion of the policy was adopted in 2008 and a three-year grace period of qualification followed.)

## Registering and Qualifying Teams

The state Science Olympiad organization is responsible for registering and qualifying all Science Olympiad teams. In the case of a public, private, charter, cyber or other alternative school Science Olympiad team, a roster signed by the principal of the school is considered proper validation. In the case of a Home School Team, a roster signed by the President of the home school association or the head of the independent home school is considered proper validation.

## Investigation of Team Qualifications

If a state Science Olympiad organization suspects that a team is comprised of students who are not members of that school's student body or that a team is not legitimate, the Science Olympiad State Director may ask the coach to provide verification of that team's qualifications as follows:

- A public, private, virtual or charter school student's qualification may be verified by some form of school identification, school roster, recent report card, evidence of residence in the school district or other similar documents appropriate to the situation.
- A home-schooled student's qualification may be verified by the student's annual notice of intent to home school and some proof of residency within two contiguous designated counties.

State Directors or officials may not contact individual students to determine qualification. All inquires must go through official channels that are relevant to and can confirm the student's enrollment status, such as the administrative offices of a school district, private school, charter school or virtual school, or the registered Home School Team coach or head of an independent home school.

## Sanctions for Non-Qualified Participation

If, after investigation, the State Director determines that a team or its members are not qualified, it may impose a sanction that may include disqualification of a student team member, disqualification of a team coach, or a team's disqualification from a tournament. In the event of multiple cases of disqualification, a coach or team may be barred from future competition.
\#\#\#
Reviewed at the Annual State Directors Meeting on May 23, 2011
Ratified August 29, 2011, by the Science Olympiad Executive Board

## Appendix W: IRB Approval Letters

UNIVERSITYOF
ARKANSAS

## To:

JulieAnna Darnell Rohde
From:
Douglas James Adams, Chair IRB Committee
Date:
Action:
Action Date:
01/24/2019
Expedited Approval
01/24/2019
Protocol \#:
1807133773
Study Title:
The Secondary School Science Olympiad Experience: Student and Coaches Opinions Toward and Attitudes Regarding Participation and Potential for Science Content Acquisition

Expiration Date:
11/29/2019

## Last Approval Date:

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.
Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.
cc: Bill McComas, Investigator

## To:

From:

## JulieAnna Darnell Rohde

Douglas James Adams, Chair
IRB Committee

## Date:

Action:
Action Date:
Protocol \#:
Study Title:
Expiration Date:
Last Approval Date:

Expedited Approval
08/22/2019
1807133773A001
The Secondary School Science Olympiad Experience: Coaches Opinions Toward and Attitudes Regarding Participation and Potential for Science Content Acquisition
11/29/2019
08/22/2019

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

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cc: Bill McComas, Investigator

| To: | JulieAnna Darnell Rohde |
| :---: | :---: |
| From: | Douglas James Adams, Chair IRB Committee |
| Date: | 11/27/2019 |
| Action: | Expedited Approval |
| Action Date: | 11/22/2019 |
| Protocol \#: | 1807133773R001 |
| Study Title: | The Secondary School Science Olympiad Experience: Coaches Opinions Toward and Attitudes Regarding Participation and Potential for Science Content Acquisition |
| Expiration Date: | 11/29/2020 |
| Last Approval Date: | 11/30/2019 |
| The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects. |  |
| If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB. |  |
| It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date. |  |
| Protocols are approve expiration date withou review. Failure to rece approval of this protoc published as research | aximum period of one year. You may not continue any research activity beyond the ee approval. Please submit continuation requests early enough to allow sufficient time for val for continuation before the expiration date will result in the automatic suspension of the ation collected following suspension is unapproved research and cannot be reported or you do not wish continued approval, please notify the Committee of the study dosure. |

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cc: Bill McComas, Investigator

To:
From:

Date:
Action:
Action Date:
Protocol \#:
Study Title:

Expiration Date:
Last Approval Date:

JulieAnna Darnell Rohde
Douglas James Adams, Chair IRB Committee
02/28/2020

## Expedited Approva

02/28/2020
1807133773A002
The Secondary School Science Olympiad Experience: Coaches Opinions Toward and Attitudes Regarding Participation and Potential for Science Content Acquisition
11/29/2020
02/28/2020

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

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cc: Bill McComas, Investigator

To:
From:

Date:
Action:
Action Date:
Protocol \#:
Study Title:
Expiration Date:
Last Approval Date:

JulieAnna Darnell Rohde
Douglas J AdamsJustin R Chimka, Chair IRB Expedited Review
01/31/2022
Expedited Approval
01/31/2022
2110364612
The Secondary School Science Olympiad Experience: Coaches Opinions Toward and Attitudes Regarding Participation and Potential for Science Content Acquisition
11/18/2022

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

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cc: Bill McComas, Investigator


[^0]:    William F. McComas, Ph.D.
    Dissertation Director

