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An Investigation of Technology Implementation through the Lens of Student Centered Learning and the Technological Pedagogical Content Knowledge Paradigm

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AN INVESTIGATION OF TECHNOLOGY IMPLEMENTATION THROUGH THE LENS OF STUDENT CENTERED LEARNING AND THE TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE PARADIGM

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ABSTRACT

AN INVESTIGATION OF TECHNOLOGY IMPLEMENTATION THROUGH THE LENS OF STUDENT CENTERED LEARNING AND THE TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE PARADIGM

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Dissertation supervised by David D. Carbonara, Ed.D.

National statistics show that there are increases in access and availability of computers, and technology, in both the classroom and students' personal lives (Culp et al. 2005, Hoffman & Ramirez, 2018). However, Tas (2017) and Wachira and Kenngwee (2010) posit that there is stagnation, even declines in certain cases, of the integration of instructional technologies in delivering student center learning in the classroom. This decline is even more prevalent in the science classroom (Vickrey, Golick, & Stains, 2018). Teachers face many challenges in the classroom; especially when technology integration is considered (Blackburn, 2016). This study seeks to determine which conditions exist to create this decline and stagnation, and offer practical solutions to overcome them.

A qualitative study was implemented to determine what training educators receive to deliver science content using technology, and also examine what activities and tools are being used in the secondary science classroom. The greater Pittsburgh and Allegheny County educational district was selected for this study. Results were examined through the lens of the Technological Pedagogical and Content Knowledge (TPACK) paradigm and Substitution Augmentation Modification Redefinition (SAMR) model, with focus on student centered learning (SCL) activities.

An initial survey was completed by 51 teachers, and six teachers were selected for follow up interviews as a part of this study. Those teacher represent both high and low implementers of technology in their classroom, based on their self-reported used of technology. Technology was found to be used on a daily basis on each of these classrooms, however, it was found that no pedagogical training was given to any of the teachers before implementing new technology. True TPACK was only found in two teachers, with daily use of SCL being found in each classroom. No correlation was suggested by increased SCL activities and TPACK, as teachers were employing many SCL activities without TPACK. Only two of the teachers studied offered tasks on the higher levels of SAMR, modification and redefinition.

Three major themes emerged from this study: 1) positive views of technology with no pedagogical training, 2) favorable views of SCL with daily classroom integration, 3) and lack of district or administrative support. Barriers were found in three categories of SCL: pragmatic, pedagogical, and technological.

This study shows that teachers want to use technology, and see it as valued tool. It was discovered that teachers are not being given the tools they need to created technology infused classrooms that represent true TPACK.

DEDICATION

Des Places. Libermann. Hogan. French. McCloskey.

This dissertation is dedicated to the Congregation of the Holy Ghost, the Spiritans, who have fought, and continue to fight, to make education accessible for everyone. For over 300 years they have reminded the world that it is essential that you be open, simple, and gentle with everyone. For the last 15 years they have served as mentors, and guides, for me of how to live in community and serve those that may find themselves on the margins, wherever that may be.

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LIST OF ABBREVIATIONS

SCL: Student Centered Learning

TPACK: Technological pedagogical content knowledge

TK: Technology knowledge

CK: Content knowledge

PK: Pedagogical knowledge

PCK: Pedagogical content knowledge

TCK: Technological content knowledge

TPK: Technological pedagogical knowledge

SAMR: Substitution, Augmentation, Modification, and Redefinition

STEM: Science, technology, engineering, and mathematics

Chapter 1: INTRODUCTION

In a report to the Nellie Mae Education Foundation it was discovered that in public schools there is a 4:1 ratio of student to computers coupled with an eager teacher population; many who have had instructional technology as a part of their pre-service curriculum (Meoller, & Reitzes, 2011). However, this report shows that out of 1,000 high school teachers surveyed only 8 percent fully integrate technology in their classrooms. A natural outgrowth of this statistic is that 43 percent of students report being unprepared to use technology appropriately in the realms of higher education (U.S. Department of Education, Office of Educational Technology, 2010). Given all of these statistics, instructors remain unsure of technology's place in the classroom (Susan, Greenberg, & Walker, 2017).

Furthermore, scientific literacy among the general population is not increasing, even as current events and political issues rely heavily on a basic understanding of science (Klucevsek, 2017). The Pew Research Center recently surveyed scientists and the general public for their opinions on scientific issues. When issues regarding prevalent topics such as climate change, genetically modified foods, or stem cells were surveyed the responses of Americans had significantly large gaps in agreement (Pew Research Center, 2015). It was found that, often, scientists and the average population shared very different opinions on the presented topics.

When considering the difference in public opinion on scientific issues, and a lack of understanding of scientific principles, two out of five Americans report belief that there is a shortage of workers for the scientific and engineering fields. However, current students are twice as likely to consider STEM (science, technology, engineering, and mathematics) fields as a career (Emerson, 2016). Of these students surveyed, only 30% believed that their schools had the necessary resources to prepare them for careers in the STEM field.

One promising approach to address these issues is the theory of student centered learning, which can be further enhanced by proper integration of instructional technology. This study seeks to explore what conditions exist that limit the introduction of technology integration and student centered learning environments in the secondary science classroom. While the benefits of student centered learning are being recognized, so are the challenges with implementing it. A recent case study highlighted common themes that emerged when it came to educators' difficulties with implementing student centered learning environments in the classroom (Aslan & Reigeluth, 2015). The common themes were divided into areas relating student mindset, time and resources, and consistency. It was determined that changing the student mindset towards directing their own learning was the first hurdle, then followed by the time is required to implement this properly, and finally an overarching theme of consistency. It was determined that consistency was needed between teachers, classes, grades, schools, and educational legislation, as these factions could be found to disagree with each other (Aslan & Reigeluth, 2015).

Student centered learning

The convergence of educational standards, accountability, and funding calls for an analysis of how students are educated and also queries the mode of instruction educators are using to deliver content. The educational strategy of student centered learning has gained traction lately in the minds of educators, as the demands placed upon the educational experience and its students are increasing; both by internal and external demands (Lyke & Frank, 2012; Sala, Knoeppel, & Marion, 2017). Internally, institutions of higher education are looking for a way to offer students an individualized learning experience which builds on their education in the secondary education setting, with the additional goal of staying on top of current practices in both technology and education (Santoso, Schrepp, Utomo, & Priyogi, 2016). The method and strategy of student centered learning has many benefits to the educator, the student, and other key stakeholders in the educational process. In a broad sense, students transition from passive to active learners; which ultimately encourages creativity, originality, and responsibility. Additionally, students gain an increased learning ability characterized by collaborative work, professional development, and critical thinking (Msonde & Msonde, 2017). This leads to an improved relationship between the parents/guardian and students, as homework becomes less of a struggle to complete and more of a continuation of the students' active learning process (Kaput, 2018). Another key result of the aforementioned continuum is an improved relationship between the student's parent/guardian and the teacher. These are important considerations, given the knowledge that consistency between all of these parties is crucial for proper implementation of a student centered learning environment.

There are two ideas of student centered learning are comingled in the minds of most educators. First, there is a broad idea that student centered learning simply refers to the idea that educators must recognize that each student learns differently, and subsequently the instructor must act as an individual facilitator and not an instructor for the entire class (Broad & Felder, 1996). Student-centered learning as a broad theme evolved as a result of changing beliefs and assumptions related to the role of individual in learning (Çubukcu, 2012). This approach puts focus on the student and calls for differentiated instruction in the classroom. This broad classification of instructional methods is in response to what most researchers would call 'teacher centered learning'. Teacher-centered learning places the instructor(s) in an active role, with the student in a passive role (Roberson & Woody, 2016). In contrast, student-centered learning places the student in an active role, with the ability to drive their own learning experience (Martell, 2015). Student centered learning can manifest in the instructional approaches of project based learning, digital learning, individualized learning, simulations, small group work, inquiry based learning, and interactive debate, among others (Lee & Hannafin, 2016). The common factor to all of these methods, or strategies, is the ability of the student to prioritize their learning and give them some autonomy over their own learning process.

A hallmark of student centered learning is the aforementioned ability of a student to have ownership over their learning process and achieve personally meaningful learning goals, while teaching autonomously (Lee & Hannafin, 2016). In addition to offering a different relationship with all students, student centered learning offers significant growth in offering education to populations that may not otherwise have access to instruction. Blended classrooms that merge face to face instruction with individualized digital learning have proved transformational in offering access to rural students (Kellerer, et al., 2019). The ability to personalize a lesson for an individual student has proved useful in education for students with disabilities, where individualized instruction is often a part of an accommodation plan (Rhim & Lancet, 2018). Personalized learning has also proved to be beneficial when looking at how minority students are educated (Dingerson, 2015; Grapin, S., 2019). There have also been gains in the type of personalized content that can be offered, as topics as diverse as sexual education can be transformed using student centered learning methods (Kulik, Brewer, Hilemn, 2019).

Second, and of importance to this study, is the theory of student centered learning that calls for action in five domains of distinct learning environments: psychological, pedagogical, technological, cultural, and pragmatic (Hannafin & Land, 1997). Overby (2011) further delineates the five domains of student-centered learning environments. The first domain of a psychological foundation is focused on how students think and learn, as individuals in a student-centered learning environment. The pedagogical domain specifically aims to examine the methodology, activities, and inherent structures of a student-centered learning environment, such as a flipped classroom. Together, the pedagogical and psychological domains form the basis of how content is organized in a classroom to promote SCL. The technological domain seeks to optimize new, and available, technologies to achieve a desired outcome in the classroom to promote a SCL, such as blended classroom with personalized technological tools. Culture can often play an important role in the development of a student centered learning environment. Educators must consider this domain as each society, or region, has a different design for their classroom or educational system. Lastly, one must look at the pragmatic foundations of a student centered learning environment. Educators cannot consider the prior four foundations without examining the availability of certain technologies, budget constraints to purchase and implement, or on a basic level, the time it takes to implement a new technology or lesson (Felder & Brent, 1996).

This idea calls for a balanced approach in the classroom that takes on increased significance when proper technology integration is the ultimate goal; as the application of technology in education does not necessarily equate to effective forms of learning (Blackburn, 2016). As current educational policies are aimed towards improving students' academic achievement toward specific student learning goals, educators must have sound models guiding classroom instruction; given that policies and funding are usually tied to measureable standards (Sala, Knoeppel, Marion, 2017). The examination of student centered learning, and the five associated domains, becomes even more significant as the last sixty years of educational research questions the relationship between resources and achievement (Archibald, 2006).

There are many educational domains that make up a balanced student centered learning environment. A critical understanding of what characterizes a student centered learning environment, or fully integrated classroom, is necessary as these activities are ultimately guided by the five aforementioned defined learning domains. Each domain has an effect on the activity that must be considered before using in a classroom (Wong-Lo & Bai, 2013).

First, and most basic, in a student centered learning environment, the teacher considers the needs of the student, and then provides appropriate classroom instruction based on that informal and real time assessment of classroom needs. Students with different learning needs are accommodated, and the instructors insure that students appropriately understand the information before moving on to more difficult material. This beginning step of implementing a student centered learning environment is intrinsic to the psychological domain of the model, as an educator must begin by considering how a student will process information (Harden & Crosby, 2000).

The second area looks at the type of classroom activities teachers' offer to their students, with a direct correlation to the pedagogical models in place in a classroom. These activities need not be classified as "hands-on" or "group work", but often are. The teacher provides direction and redirects the student(s), and classroom, if needed. The type of activity is not what makes the task an important piece of student centered learning, but rather the need for active student engagement is. This is what the hallmark of a student centered learning environment becomes (Harden & Crosby, 2000).

Third, an important method of instruction is characterized by the teacher giving students a problem, or assignment, without giving students full direction on the individual steps needed to complete the problem (Saye & Brush, 2001). Students will presumably try a step that will not result in the correct answer. Here, the teacher will actively question students on these steps, but still not give them the answer. Naturally, they will turn to their peers for support; which builds a collaborative environment in the classroom. Student collaboration is essential for student centered learning. Lastly, the instructor presents a topic to the class and each student is able to determine which aspect of that topic is of direct interest to them for exploration. In this situation students can be working on a wide variety of assignments that all relate to each other; directly or indirectly. If the students encounter difficulty, the teacher does not give the answers, but provides a line of inquiry guiding them to the next step. Ultimately, the goal is for each student to present their findings to the classroom. This allows for the student to take ownership of the learning experience and offer new ways of thinking about a topic to their classmates (Overby, 2011).

The technological domain of student centered learning specifically addresses ways in which content can be delivered using technology. Student-centered learning environments are designed to provide students with opportunities to take a more active role in their learning, using a wide variety of tools. Recently, online chats, wikis, blogs, instant messaging, and digital storytelling have become commonplace features of a student centered learning environment (Atkinson, Swaggerty, Mays, & Fink, 2011).

The cultural domain of a student centered learning environment cannot be ignored, as opinions on schooling and education are often formed over many years, based on cultural values and norms. Implementation of new student centered learning activities that do not account for the context of the learner will often fail to connect with the targeted learners. For example, in a culture where students are taught not to question their teacher, or engage in conversation, altering the teaching strategy to have the student drive their own education will take careful consideration to implement (Bekele, 2016).

A comprehensive understanding of how educators perceive and experience these methods of instruction, and the pragmatic approach that can be used to implement this environment, is valuable as this can greatly affect their development as a professional and alter the outcomes of their classroom (Wong, 2016). Even though student centered learning, and the tasks offered by it, have proved to be a valuable tool in the classroom, many educators, specifically those in science classrooms, struggle with implementation (Luft, Wong, Ortega, Adams, & Bang, 2011). However, before that one must understand the five distinct domains that contribute to a balanced technology enhanced student centered learning environment.

Of the five recognized student centered learning domains technology often receives a greater emphasis, as it believed to have the ability to transform teaching and learning in a rapid way (Toh, 2016). Given this, many teachers experience additional barriers associated with implementing technology with student centered learning in the classroom (Murthy, Iyer, & Warriem, 2015).

Technology in SCL

When an educator looks at the technological domain of student centered learning, there is an emphasis placed on what the capability of a technology is and then subsequently, what the limitations of the technology may be. Once the possibilities and limitations are known, the goal of the educator is to develop a classroom activity that uses technology to produce a new way of exploring a given topic. The continual challenge for educators is using technology appropriately, while considering the other four domains. For example, the use of technology without sound pedagogy is not going to ultimately lead to a student centered learning environment. With better integration of these five domains, there is a better chance of success in the classroom, for the student and educator (Hannafin & Land, 1996).

The learning domain of technology is oftentimes given the most attention out of the five domains of student centered learning. There are many reasons this may be the case. Foremost, mobile devices are a critical part of most students' lives. The use of mobile devices has the potential to transform learning. In an effort to capitalize on student's inherent interest, many educators seek to place novel technologies in the classroom, with varying degrees of success (Nellie Mae Foundation, 2011). One of the main perceived benefits of this is that learning with mobile technology can be easily personalized based on the students' interests and needs; a critical piece of student centered learning (Romrell, Kidder & Wood, 2014). Hannafin and Land (1997) show that this continual development of technology has propelled the other learning domains forward as well.

Furthermore, promoting distance and online education is a top priority for many colleges and universities. Given the importance of this in today's higher education environment one must insure that evaluating the outcomes of student learning in this environment remains a top priority of both research and educational policy (Lyke & Frank, 2012). Because of this, proper technology use and training in the classroom remains popular as an educational topic and target for funding.

Palmer and Holt (2009) show that with proper implementation there should be no difference between the learning outcomes of students in a traditional classroom when compared to that of students in an online or cyber learning environment. However, researchers suggest that this cannot be done without the elements that make up an effective technology-based student centered learning environment: creation of a supportive classroom community, positive student attitudes toward technology, high levels of instructor interaction, and sufficient technical support (Parsons-Pollard, Lacks & Grant 2008).

The existence alone of technology in a classroom does not make a student centered learning environment. The Educause Center for Research and Analysis discovered that ninety-nine percent of undergraduate college students own one or more technological devices, with smartphones, ninety seven percent, and laptops, ninety five percent, as the top two devices. Sixty five percent of students agreed that most faculty used technology for instruction but also felt faculty did not encourage the use of technology to deepen their learning or engagement in their learning (ECAR Study of Undergraduate Students and Information Technology, 2018). They also reported wanting faculty to use more classroom technology to aid their learning (Skiba, 2018). These findings question what tools are being used in the classroom, and how they are being used.

Substitution Augmentation Modification Redefinition (SAMR) model

The inherent use of a technological tool in the classroom can be best evaluated by used of the SAMR (Substitution Augmentation Modification Redefinition) model, which offers a continuum that is split into two categories of classification for these tools: transformation and enhancement. On the baseline level of substitution, the technological tool employed by the instructor acts as a direct tool for substitution and there is no functional change in the task at hand, other than the use of a novel technology (Gromik, 2012). A step beyond substitution is augmentation, where the technological tool of choice is a direct tool substitute that offers a functional improvement. Both of these layers are classified as an enhancement of learning (Kirkland, 2014).

As progression continues, the third step in the SAMR model is that of modification. In this situation the technology requires, or allows for, a complete redesign of a task. Hamilton, Rosenberg, and Akcaoglu (2016) use the example of a secondary science class where an instructor shifts how students are able to learn about the scientific phenomenon of light. Here, the SAMR modification shifts from showing a diagram of light traveling to providing an interactive computer simulation of light where students can manipulate variables and observe differences. The final layer, and most desired, is redefinition. In this state the technology will offer the creation of a new task, which would have been inconceivable before the introduction of the specific technology in the classroom (van Oostveen, Muirhead, & Goodman, 2011). Hamilton, Rosenberg, and Akcaoglu (2016) offer the situation where an instructor traditionally requires a social studies persuasive essay. Rather than the traditional essay the instructor will now require students to create and present their arguments on their given topic through individually created and edited videos.

The SAMR model is not a timeline in which educators should travel through the duration of their course. Certain tasks that would be categorized as enhancement tasks, substitution and augmentation, can certainly serve useful purposes in the classroom. For example, word processing has many benefits over traditional handwriting; but does not offer a new way of learning or a novel instructional method in the classroom. Technological tasks that would be grouped under the transition half of the model do offer this, by offering opportunities for learning that could not have taken place without the technology. A basic example employed in many classrooms is a shared collaborative document available to students available online 24/7 that offers collaborative writing and knowledge creation opportunities not otherwise possible (Kihoza, Zlotnikova, Bada, & Kalegele, 2016).

Using technology effectively in the classroom is the ultimate goal of the SAMR model, and many educators. Educators must understand that truly using technology in an effective way depends on creating tasks and assignments that alter the traditional way of learning; which ultimately creates a classroom experience that would not exist without the use of technology (Eynon, Gambino, & Török, 2014). Certainly those tasks seen as substitution and/or augmentation serve many useful purposes, but they are not truly using technology to create a richer learning environment (Puentedura, 2012). Learning activities that are demonstrative of both modification and redefinition can transform a classroom experience for a student. When examining these higher levels of the SAMR framework, the full potential of technological tools can be realized (Hockley, 2013).

Hannafin and Land (2000) describe the technological domain of student centered learning as the broad idea of 'enabling capabilities'. This can show what is merely possible with technology, not what is necessarily required or even desired. Looking at this one domain, in relation to four others, represents both the capability and limitations of technology; and how they can be optimized for student success. Different models of inquiry, and classroom instruction, are now possible because of technology. The challenge that most educators face is not one of how to invent new models of learning, but how to optimize those models with technology as new technology becomes available. This optimization of the technology to support SCL will often depends on educator's knowledge of content, pedagogy, and technology.

Technological Pedagogical Content Knowledge paradigm integration

Integrating technology in the classroom brings two main issues to the forefront of education: both how to teach and how to learn. Both are complex and dynamic issues that can be enhanced with the integration of technology (Mishra and Koehler, 2006). A particular framework that unifies these concepts is known as the Technological Pedagogical Content Knowledge paradigm, or "TPACK". This fundamental unifying framework examines both teaching and learning through the lens of technology integration. There are seven knowledge bases that relate and build on each other to illustrate the paradigm. Those knowledge bases are: content knowledge, pedagogical knowledge, technical knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge and technological pedagogical content knowledge (Mishra and Koehler, 2006).

Content knowledge, (CK), is the actual subject matter being taught. This paradigm demonstrates that understanding and organizing the base content is the first step to proper technology integration. Pedagogical knowledge, (PK), are the classroom methods employed to convey knowledge; such as a student centered learning approach. Technological knowledge, (TK), is the technological framework of the model; such as the ability to use the software package/tools critical to the lesson. Pedagogical content knowledge (PCK), first conceptualized by Shulman (1986), is described as the way of presenting the content so that others can understand it; oftentimes thought of as teachability. Technological content knowledge, (TCK), is the actual design and use of technology in relation to transforming the content being delivered to ultimately give a new perspective on the content. Technological Pedagogical Knowledge, (TPK), is the knowledge of how to enhance pedagogical processes with the use of technology (Pamuk, Ergun, Cakir, & Ayas, 2013).

Finally, at the intersection of all the other domains of knowledge, is technological pedagogical content knowledge (TPACK). This is the use of technology to support content-specific pedagogical strategies. Harris and Hofer (2009) best describe this as the intersection of teachers' knowledge of curriculum content, pedagogy, and technology. The crucial aspect this paradigm highlights is the knowledge of how to use technology to implement teaching methods for various types of content matter.

Activity Types

Harris and Hofer (2009) further expand the TPACK model with the introduction of activity types and an associated taxonomy for classification. They describe activity types as conceptual planning tools for teachers in an effort to give a methodological shorthand. This is useful as it can simultaneously build and describe plans for student centered learning experiences. Available research has delineated forty-two activity types to categorize instructional activities. Thirteen of these are centered on student acquisition of knowledge relating to social studies content, concepts, and processes. Next, twenty-nine are focused on giving students ways of expressing their understanding of a concept. Six activity types characterize convergent learning, while twenty three are characterized by divergent learning. This amalgamation gives the following accepted three sets of activity types: knowledge building, convergent knowledge expression, and divergent knowledge expression (Hwee, 2017).

All activity types have an associated possible technological tool. For example, an activity may be something as simple as reading text. In this situation students are expected to extract information from textbooks or instructional documents. The possible technologies may be websites, electronic books, iPads, or an electronic reader.

Papanikolaou, Makri, and Roussos (2017) show that activity types do not exist to merely classify the work teachers are doing in the classroom; a useful endeavor in itself. They also exist to help educators combine activity types and offer more complex activities with a greater breadth. This breadth can be evaluated based on how many activity types are combined in a single lesson. These combined activity types offer more engaging classroom activities which often address multiple curriculum standards at one time.

Combining one or two activity types can produce an efficient and structured student-centered activity, while combining three to five offers a less short term module with convergent and divergent learning activities. Using five to eight activity types offers structured activities of varying length that allows for deeper exploration of content. The most complex offerings combine six to ten activity types and offers flexible duration, structure, content and process goals. This is used infrequently due to its complexity (Harris & Hofer, 2009). The combination of activity types under TPACK must be appropriate for the task at end. An offering that combines eight activity types is not intrinsically more useful than an activity that offers two; especially if the appropriate technology and pedagogy are not utilized. Here again, the TPACK model shows us that technology, pedagogy, and content must be appropriate for the task at hand.

As this paradigm is so robust, yet relatively new, many are calling for increased use and application of the model to verify its validity (Cavanaugh & Koelher, 2013). It has, however, been continually determined that proper understanding of the TPACK paradigm can lead to increased content-specific technology enhanced learning environments; especially in the natural and environmental sciences (Maeng, Mulvey, Smetana, & Bell, 2013). Furthermore, it has been demonstrated that teachers find this model to be intuitive and a large contributor to their own professional development (Koh, Chai, & Tsai 2012).

Problem Statement

There are considerable promises of technology in education. National statistics show that there are increases in access and availability of computers, and technology, in both the classroom and students' personal lives (Culp et al. 2005, Hoffman & Ramirez, 2018). However, Tas (2017) and Wachira and Kenngwee (2010) posit that there is stagnation, even declines in certain cases, of the integration of instructional technologies in delivering student center learning in the classroom. This decline is even more prevalent in the science classroom, often times limited to word-processing or online submission of assignments, rather than problem-solving using animations or simulations (Vickrey, Golick, & Stains, 2018). Research shows that teachers face many challenges in the classroom; especially when technology integration is considered (Blackburn, 2016). When implementing a student centered learning environment there are five recognized barriers to implementation: pedagogical, technological, psychological, cultural, and pragmatic (Hannafin & Land, 1997). This study determined which conditions exist to create this decline and stagnation, and offer practical solutions to overcome them.

Research Questions

1. What training do educators receive to implement and deliver secondary science content using technology?
2. How prevalent is the implementation of:
   - SCL in secondary science classrooms?
   - Technology in the secondary science classroom?
3. What SCL activity types are educators currently utilizing in the secondary science classroom?
4. What instructional technology tools are educators currently utilizing in the secondary science classroom?

Chapter 2: LITERATURE REVIEW

Introduction

The purpose of this study was to investigate what conditions exist in secondary education science classrooms that provide constraints for the use of technology in creating a student centered learning environment. In 2011 it was demonstrated that 60 percent of teachers reported that they use technology in the classroom, but just 26 percent of the students indicated they are encouraged to use technology in the classroom themselves (Meoller & Reitzes, 2011).

This investigation will examine the use of technology to create SCL environments in secondary science classrooms, as reported by teachers in the greater Pittsburgh and Allegheny County education district. This examination will be done through the lens of the TPACK paradigm and SAMR framework to categorize the ways in which science teachers use technology, whether technology supports SCL, and whether technology supports strong content-based and pedagogical instructional activities in the science classroom. Teachers' perspectives and current research will also be used to determine what supports can be put in place to overcome any real, or perceived, barriers towards technology integration, to enhance the use of technology to implement SCL, including strong content-area instruction and pedagogical approaches.

The first section of this literature review will examine current technology use in the science classroom. Next, the current research and trends in student centered learning will be highlighted, concluding with an overview of the TPACK paradigm and SAMR model.

Current State of Technology in the Science Classroom

As our world becomes increasingly subject to new scientific and technological innovations, the educational community needs to better prepare students to understand these innovations and to enter their related industries (Otero & Metzler, 2017). Issues such as genetic engineering, antibiotic resistance, and climate change are all at the forefront of the news and each have a unique technological and scientific component that students should understand (Kuster & Fox, 2017; Trefil & Trefil, 2009).

For many, the promise of technological advances gives hope for new methods of delivering science instruction in the classroom, as learning science proves difficult for a myriad of multifaceted reasons. In secondary science classes there is an emphasis placed on complex vocabulary, intricate mathematical equations, and invisible phenomena. All of these factors place an added cognitive load on an already difficult subject area. There are many barriers to success in learning science for students, but research has pinpointed the aforementioned three main factors (McCleery & Tindall, 1999).

Milar (2008) delineates why science learning is difficult for many students by looking at knowledge acquisition. The first barrier is knowledge of factual information, in the most basic sense science classes build upon each other. Given this inherent tiered learning structure, the beginning of any new classes relies heavily on the successful completion of another. The second barrier is one of student understanding. Learning sciences relies on a conceptual understandings of clusters of events and terminology that share common attributes. The third barrier is the need for an authentic understanding of principles that demonstrate phenomenological relationships among concepts.

Many of these items are fairly abstract and involve a lot of cognitive processing; which is why many remain hopeful that technology will reduce this cognitive overload. Some may question if you can deliver complex material of that nature online; especially in an asynchronous format. Fiorella, Vogel, and Schatz (2012) demonstrated that higher order cognitive skills can be taught online. In their 2012 study a combination of spoken and visual text was delivered with a dynamic feedback system to deliver an instructional training. It was demonstrated that those participants using the virtual training with the technological aides better retained the complex system of information delivered. Marion and Beecher (2010) make the case that because of the complex cognitive load placed upon students learning science that this content area is most ready for technological integration in the classroom.

Gaming in the science classroom

Nebel, Schneider, and Ray (2016) reinforce the idea posited by Wideman (2007) that video games in the science classroom provide multiple levels of academic support and real time progress monitoring. It has been demonstrated that 30-40 minutes of time spent playing certain educational games, with content in the sciences, can increase student achievement (Marino & Beecher, 2010). Not only is this an engaging format, but they are often internet based. This allows for use on most handheld devices, allows for extended inquiry time, and gives each student the individual time they need to understand the concept being reinforced in the game. The additional benefit of an internet based system is the chance to monitor data from the administrative end and to ultimately facilitate a performance based evaluation of each student that then offers an individualized plan for success. Similar results have also been replicated in teaching mathematics, as well as foreign language learning (Vandercruysse, Ter Vrugte, de Jong, Wouters, van Oostendorp, Verschaffel, & Elen, 2017; Craddock, 2018).

Applications in science, such as teaching pharmacy students about diabetes management, have shown positive returns when using gaming as an instructional tool. Eukel, Frenzel, and Cernusca (2017) created an escape room simulation that demonstrated student understanding and achievement in health science which were statistically higher than their traditionally educated peers. Of important note, is that this method yields bother higher achievement and engagement in the classroom.

Applications of adding gaming are also being tested for use in educating currently practicing teachers, when pursuing continuing education (Kopcha1, Lu Ding, Neumann & Choi, 2016). Choi, Pursel, and Stubbs (2017) have showed that students are motivated by the gaming principles incorporated into their courses and recognize the autonomy these gaming modules provide to the learner. Certain universities are now piloting customized gaming engines to make the use of appropriate instructional games easier across the entire institution, with applications to multiple disciplines (Choi, Pursel, & Stubbs, 2017). Instructional gaming is even making its way into doctoral studies, where it has shown to be useful in distance education and as a field site for researchers to gather information on how participants take part in the games and simulations (Snelson, Wertz, Onstott, Bader, 2017).

Instructional gaming is proposed as an aide to reinforce difficult material, not to be offered in lieu of traditional instruction. The case for augmented traditional teaching methods with instructional media is easily made due to the ability of the technology to be molded to the needs of distinct learning styles, in a personal way that traditional methods of instruction cannot provide (Castanso & Piercy, 2010).

Remote and virtual laboratories

A novel way of collecting data and performing experiments is the use of laboratory simulations. In these situations students will be given a computer software package that simulates a lab, and they have a large inventory of chemicals and instruments they can use to conduct experiments and collect data. Students may not aim to not take this seriously as combining two chemicals with a potentially lethal, or explosive, result is no longer an actual danger (Bortnik, Stozhk, Pervukhina, Tchernysheva, & Belysheva, 2017). While this is of practical benefit for safety, it may not provide a real learning experience for the student.

Even in these situations it was found that students appreciate the ability to direct their own learning and experiment at their own pace on a given concepts. As these laboratory experience are less realistic they were still found to be effective in terms of skills acquisition and students' appreciation of how to function in a laboratory environment. These findings were congruent with the underlying discovery that students are more invested in their laboratory education when they can direct their learning and move at their own pace (Al Musawi, Ambusaidi, Al-Balushi, & Al-Balushi, 2015).

At a time when the demands being placed upon a University's resources seem to be higher than ever, researchers are starting to look at physical laboratories as a target for innovation. Research has demonstrated that there needs to be a way to update the delivery of laboratory science in higher education (Tatli & Ayas, 2012).The experience of collecting data and doing original research is vital to proficiency in the sciences, but the limitations on this can often leave students struggling with success and true knowledge acquisition (Thirunarayanan, 2016).

Remote access laboratories are starting to become a more common method of educational delivery to combat the shortcomings of laboratory simulations. In the remote access setting an authentic experiment is completed with robotic tools, or scientific equipment, by a student connected virtually to a laboratory setting (Wu & Albion, 2016). For example, a student studying velocity can manipulate a robotic arm to drop a tennis ball and record the time it takes to reach a certain measurement point. Remote laboratories are in response to the idea that a digital, or animated, simulation is not an authentic lab experience (Esche, 2005). The major difference is these labs offer authentic data in real time; which simulations do not. Students learn equally well from remote access laboratories, as compared to physical labs, and they are often found to have a realistic understanding of the material (Nickerson, Corter, Esche, & Chasspis, 2007). The introduction of these labs solves both fiscal and physical issues, while still offering an authentic research experience to students that would otherwise not be able to encounter one.

While there is no true consensus on which one technology is most appropriate for delivering a laboratory experience online, many advocate for a mix of technologies. It was found that a mix of virtual laboratories, online training simulations, and visits to science centers or other scientific community-based partners can offer the same knowledge acquisition as a traditional laboratory experience (Arvanitism, et al., 2009). This stands to reason when one considers the idea that community based learning in conjunction with technological innovation provides higher acquisition of knowledge for students (Sterling & Frazier, 2006).

These forms of technology, and augmented experiences, are distinctly different from the previous findings on video games. A laboratory simulation seeks to replace the traditional lab setting; while video games do not seek to replace traditional classroom instruction. In all situations, educators should clearly examine the purpose of the technology being used. These educators should consider which pieces of a lesson, or topic, are being replaced with technology and which are being enhanced (Taber, 2011). One characteristic that is the same between both technologies, however, is that the characteristics of students in the sixth grade to higher education range age group, often termed emerging adults, make them ideal candidates for using instructional media and offering different methods of instruction (Arnett, 2000).

Some argue that physical labs take up precious space and students should practice first in simulations, others argue that the real environment is critical to learning. There is a third faction that advocates the uses of remote access labs first suggested by Nickerson, Corter, Esche, and Chassapis (2007) and demonstrated by Farrell (2015) with the use of the North American Network of Science Labs Online. As there is no general consensus, many advocate for a blending of these instructional forms in the classroom (Kay, Goulding, & Li, 2018).

Instructional technology in the science classroom.

Great strides have been made in the application of instructional technology to science education. Easy to use probes for temperature, voltage, and conductivity have been developed that allow chemical experiments to be done with handheld technology (Supalo et al., 2007). Educators must examine how these technologies affect science education, as this can translate into increased graduation rates and overall academic success in STEM areas.

Sun, Rye, & Selmer (2010) have demonstrated that even at the middle school level, that the integration of something as minor as a pedometer to replace traditional measuring methods increases overall satisfaction with and retention of material. Baytak and Land (2011) demonstrated that students could use technology to direct their own learning as early the fifth grade class level. In their study fifth grade science students were tasked with building educational games, which were functional, based around the current topics they were learning in class. This example tested that the idea that students can learn by design and also demonstrated how proper pedagogy can make the integration of technology into a class easier.

This highlights the promise that technology can offer new ways of delivering material while putting the student in an active learning role. This can be seen as a direct result of earlier concerns raised by studies that question how educators can bridge the gap between younger students' technology usage outside of the classroom and technological innovation in the classroom (Lee & Spires, 2009). This research shows that students certainly use technology out of school. In a general sense students are not doing this to learn, but to socialize and entertain themselves. Given this, students enjoy using technology in the classroom. Proper use of student centered learning tools can lead to the meaningful integration and planning of technology

These examples of how technology is used to teach science have a definite parallel to how technology is being used to give scientists better results, and the ability to attain them quicker. Something as basic to scientific education as imaging a cell has become streamlined with the use of X-ray diffraction (Flannery, 2005). Perhaps the biggest trend in analytical science education is the use of mass spectrometry to enhance, or replace, traditional methods such as chromatography columns (Sobel, Ballantine, Ryzhov, 2005). Mass spectrometry has even found its way into areas as diverse as fingerprinting and protein sequencing (Counterman, Thompson, & Clemmer, 2003). Mass spectrometry has become an integral part of all chemistry coursework done at the collegiate level (Kooser, Jenkins, & Welch, 2003). Many chemists report having their first encounter with mass spectrometry in the 1980's or 1990's. However, it has now become integral to biology, chemistry, and the pharmaceutics industry; which are all important pieces of the secondary science education arena. As the technology progressed it was coupled with the standard tools of analytical science, such as the gas chromatograph; which itself had replaced the practice of chromatography columns (Shaw, 2009). As technologies have evolved so have the strategies used to employ them together. Betts and Palkendo (2017) have demonstrated that these novel technologies can be combined with each other to offer previously impossible experiments to students; using an innovative approach to introduce undergraduates to liquid chromatography–tandem mass spectrometry. Consequently, the instructional technology being used in the classroom must continue to rapidly develop to keep up with these scientific innovations (Gurbuz, 2016).

Pedagogical Approaches

The tools in which students learn science are not the only forms of innovations. The spaces and environments in which instruction is delivered have also evolved. The Wiki forum is an ideal medium to exchange information and comment on each other's work within the group; as well as being able to see what other members of the class are finding and comment appropriately. Current research makes the case for the use of wikis for qualitative research, based on the ability of the wiki to be molded to the needs and interests of the researcher (Castaños, 2010; Reinhardt, 2019)

Collaboration is vital to the discovery and exploration of new scientific ideas and methods. Gibbons points out that online collaboration is a quick and simple method to motivate learning and it also allows students that may be otherwise hesitant to have a voice in the discussion (2010). A study by Brunsell and Horejsi (2010) examined student use of a wiki in place of a poster presentation in a biology class. In this class students reported that they were able to equally contribute to the final product as well as easily comment on each other pieces of the final project. The article points out students can build on each other's material over time, so that they can learn from and expand upon the work done by previous students. All of these things make it an ideal medium to experiment with in science education.

Advancements have even been made in the textbooks and source materials that students use in the classroom. Schools have shown positive gains in achievement when replacing traditional paper textbooks with interactive digital textbooks (Heider, Laverick, & Bennett, 2009). With the available technologies of digital media, programs and applications, and instructional technology tools educators can now create real life scenarios online to stimulate scientific thinking in their students. This is a crucial cross section, as it has been shown that a classroom relation to a student's "real world" is necessary for stimulating scientific inquiry (Jong, 2012). With all of these tools available science educators can now easily examine students' motivation, or lack thereof, in the classroom and design a module for each student (Kim, 2012).

A 2013 study demonstrates that an educator can meld technology use, assessment tools to measure learning outcomes, and technology to deliver science even in a distance setting. A constructive alignment process was employed, which clearly mapped learning outcomes and activities, to determine appropriate assessment tools. These blended laboratory courses featured custom, home experimental kits and combined elements of online and hands-on learning (Brewer, Cinel, Harrison, Mohr, & Christina, 2013).

With all these developments in scientific technology and education, and the subsequent introduction of instructional technology into the laboratory and classroom, one could question how this truly translates into scientific knowledge acquisition for students. The studies previously cited show that these technologies are a true gateway into highly valuable areas; similar to the development and testing of new drugs and cellular imaging.

While instructional technologies applied to science are versatile and useful, it was found that the implementation of these new instructional technologies in the science class has been slow (Leddy, 2010). The previous studies demonstrate that these technological tools are of great use, but educators should keep in mind that the scientific content is equally important to consider. Brown, White, and Sharma (2015) make the case that the natural sciences, specifically chemistry, are essential for a well-balanced education. Learning science provides transferrable skills of collecting data, making hypotheses about experiments, and examining results are transferrable skill sets that students can apply to any area of study.

Of course when new technology is being implemented the natural question to ask is if it truly enhances learning, or allows the student to learn new, and more complex, topics and information. A (2015) study by Sudha and Amutha examined mean difference between the achievements of pre-test and post-test scores taught by traditional methods. They found that there is a greater mean difference between the achievements of pre-test and post-test scores with a multi-faceted and dynamic web based instructional method. This is attributed to the truly multisensory experience provided to the students; which would be impossible without the aforementioned technologies. The purpose of this study is to examine what barriers exist in the implementation of technology in the science classroom, and how the educational community can overcome them to develop a student centered learning environment.

Using Technology to Support Student Centered Learning

The application of student centered learning focuses on three main educational principles as an overarching guide: 1) the ability and potential to provide equitable access to necessary skills for all students, 2) a focus on mastery of skills, and 3) consistent alignment with research on how people learn (Moeller & Reitzes, 2011). As those three principles continue to be highlighted and developed many educators turn to technology as the best way to advance and implement student centered learning. While the application of technology to the idea of student centered learning may be new; however, student centered learning as a concept has been in development for over one hundred years (Attard, Di Iorio, Geven, & Santa, 2010; Brown, 2003). The majority of what happens in secondary classrooms, and in the higher education setting, is based on an outdated model of delivery, characterized by the transmission of material from teacher to student in a passive manner which culminates in a comprehensive examination. This is in direct contrast to the notion of student centered learning.

A significant amount of research is being done in the domains of Student Centered Learning environments identified in Chapter 1: psychological, pedagogical, technological, cultural, and pragmatic (Hannafin & Land, 1997). According to the model all five domains of student centered learning should be carefully amalgamated with a balanced, integrated technology-enhanced student centered learning environment in the middle (Hannafin & Land, 1997).

The student centered learning environment itself is nuanced and can provide a multitude of different experiences under the guidance of the educator. It was determined that educators' attitudes towards certain methods will indeed change over time. As many educators may have a hesitation, or even disdain, for changing their teaching methods it has been shown that these opinions are not immovable (Avraamidou & Zembal-Saul, 2006). This is a crucial piece of the student centered learning puzzle; as it has been shown that teachers' comfort with student center learning methods has a direct correlation to how student's engage with the material. Smith and Stitts (2013) show that student engagement, and willingness to try new instructional methods, both increase when there is positive feedback from their instructors.

There are many new approaches to technology integration, under the umbrella of student centered learning, that are noteworthy to this study. In 2009, the concept of a "School of One" was piloted with great acclaim due to measureable rises in student achievement. This novel concept put technology to use with individual students, which was customized to their own content knowledge and technological skill level (Light, Cerrone, and Reitzes, 2009). In this situation students were given a daily pre-test and then subsequent assignments and tasks, with appropriate technological tools, to help them better acquire the content knowledge. This example clearly demonstrates how the intersection of pragmatic, technological and pedagogical advances can increase student performance. In a similar scenario by Ysselkdyke & Bolt (2007), specific to mathematics education, a class was given a short computer adaptive test that gave dynamic results, which would move them on to various tiered instructional levels. Each level would generate new problems for students to solve. Real time data was sent to the instructors of the class to creative individualized instruction plans. The researchers found that in this situation scores did not rise when teachers were not diligent with this as a daily form of instruction. When looking at student centered learning's foundational principles, it becomes further apparent that the technology was working, but something was lacking in a less than pragmatic approach, which may be an effect of the lack of proper pedagogical grounding.

The state of Washington has implemented a form of Student Centered Learning called Diagnoser; a computer program which generates in class quizzes based on state educational standards and benchmarks (Thissen-Roe, Hunt, & Minstrell, 2004). Feedback is given on correct or incorrect answers and prompts the student with new ways of approaching the topic until correct answers are given. Critical to the success of this implementation is the combination of the tool itself, associated resources, administrative guides, and teacher implementation help. Here, again, research shows that success in student centered learning lies at the intersection of the five domains. The approach, pedagogy, and technology were all appropriate to the challenge at hand for the school districts. Automated response systems are able to provide larger classroom similar data (Caldwell, 2007).

Similar to the feedback response loop of the Diagnoser tool, large classrooms can provide their instructor with real time data that gauges their understanding on a handheld device. A professor with 400 students cannot take that moment in time to create, and launch, hundreds of modified lesson plans; but they can redirect the lecture or emphasize topics that an entire faction of the class may be not obtaining accurately. These modified and individualized plans form the necessary skills for critical thinking in the student population; which will allow them to carry the materials presented towards professional and personal achievement (Distance Learning, 2013).

Here the importance of pedagogy becomes increasingly apparent; as the educator will need to be equipped with the knowledge of how to make sudden changes to a lesson plan to illicit the desired student achievement outcomes. It has been demonstrated that faculty teach, and deliver content, in distinct patterns that can be often hard to break (Stedman & Adams, 2012). These patterns can often be guided by perceptions of content and limitations than actual barriers.

In Clark's 2016 study this was further examined with an in depth look at three different online platforms (discussions, voice thread, and Blackboard Collaborate) impacted the types of conversations that students had around the content being delivered and with each other. It found that students each have a distinct preference, but learning outcomes were the same for each platform. This shows that the appropriate selection of technology is a critical part of properly implementing a student centered learning environment; as students are driving their retention of material with their preferred technological tool.

In 2006 it was demonstrated that another area of development in the implementation of Student Centered Learning practices is the use of digital portfolios and wiki spaces (Means). These portfolios serve as a compendium of student work, which can exist in a wide array of formats; music, images, text, documents, etc. These portfolios can document higher order thinking and understanding in ways a multiple choice test was rapid feedback cannot (Cramer, 2009). As the medium is incredibly versatile, so are its applications (Gibbons, 2010). Students can potentially maintain these for many years and educators can track student progress in many different domains, based on their own educational journey and interests (Castanso & Piercy, 2010). These varied forms on team based learning continually show that student achievement is higher; as well as student engagement in the material (Peterson & Carrico, 2015).

With the advancements in instructional media and technological tools available in the classroom, policy implementers may question the method in which education is delivered in a much broader sense: the actual school and classroom setting. Student centered learning lends itself well to expansion beyond a traditional brick and mortar school location. This can be conceptualized as an entirely on-line virtual school program or supplemental assignments and homework to be done after the school day is over. It has been demonstrated that students that participate in some form of online learning will actually perform better than their counterparts that receive solely face to face traditional instruction (Means et al, 2009). This is in line with the principles of student centered learning, as this offers the chance for students to drive their learning and educators have the additional benefit of being able to work with student in a one on one format. Here, the educator can then assess each student and determine their individual needs, strengths, or deficits. In all of these virtual, and online worlds, the underlying theme remains that increased contact, by any means, between the teacher and the student results in positive gains in the classroom (Gorsky, Capsi, & Tuvi-Arad, 2004).

A new community developed by the Massachusetts Institute of Technology (MIT) and The University of California, Los Angeles (UCLA), Scratch, is using methods of media production to deliver student centered learning in the after school environment (Peppler & Kafai, 2007). Scratch is a programing environment that allows students to create animated stories and interactives presentations at their own pace. The students’ creations are uploaded into a shared space that other community members can view. Three main outcomes have been observed from using this student centered learning tool: technological fluency that is applicable to other programs, high student engagement in their own learning process, and the ability to connect students' interests with their acquired knowledge from the classroom. The Adobe Youth Voices program builds on these principles and trains educators in technological and pedagogical strategies (Adobe Youth Voices, 2010). This program uses a model where educators help their students examine cultural topics, or current events, and place them in multimedia presentations that can be shared in multiple platforms. Students in these modules have demonstrated a higher engagement in their own learning process; while gaining a technological tool that is applicable to all forms of content knowledge.

Finally, one must determine if the online environment of a classroom is augmenting learning, or seeking to replace traditional instruction. In blended, or hybrid, online environments there is the opportunity to include additional instructional elements. O'Dwyer, Carey, and Kleiman (2007) make the case that one cannot contribute that aforementioned increase in success to the existence of the online medium alone. The online learning environment can be divided between synchronous and asynchronous classroom set up. As is always the goal of student centered learning, it should be carefully considered which environment is the best for a specific population. Synchronous instruction happens in real time over the internet and provides direct instruction.

The benefit of this method is that teachers can receive immediate information regarding their class and provide clarification on difficult lessons. Asynchronous instruction happens with a delay and information is usually preloaded with weekly benchmarks. The advantage of this is that students can work at their own pace, and spend longer on difficult principles and hasten their pace with familiar topics. Here, again, pragmatic needs must be balanced with proper pedagogy and technology. These forms of student centered learning have demonstrated positive student retention trends; which are critical when considering the pragmatic nature of budget constraints in the today's education systems (Ahuna, Tinnesz, & Vanzile-Tamsen, 2010). In all situations physical and fiscal resources can be saved with implementation of these methods, but this should further and expand the student experience, not deter and shorten it (Elshof, 2009).

In 2016 Kortz, Reitze, and Schmidt examined the impact of student-centered learning practices on students' perceptions of their own ability to learn, specifically in a large enrollment, introductory science class. Student-centered learning practices included required assignments, optional study tools, and supplemental learning resources. 85% of students said they were "extremely" or "very satisfied" as learners in the course and nearly 75% of the students said the student-centered learning practices should be offered to future students. This validates the notion that students will be more engaged in a student centered learning environment; specifically when they have the opportunity to determine how material is being delivered to them in, and out, of the classroom.

TPACK Learning Environment/Technology Integration

Technology is constantly changing and altering the way people live, learn, and work. The integration of pedagogy and technology into specific content areas is essential to enhance learning on the intrinsic level (Shifrer & Callahan, 2010). The Technological Pedagogical Content Knowledge (TPACK) paradigm explains how this purposeful incorporation can occur. Science is a content area that is notorious for advances that drastically change how a given experiment is performed. Science education is enhanced as a whole when the instructor uses their knowledge of technology and creates effective learning modules; specifically with the TPACK paradigm (Graham, et. Al, 2009).

There are three different knowledge bases in TPACK that intersect and can be applied to the classroom. Those knowledge areas include: Content Knowledge (CK), Pedagogical Knowledge (PK), Technology Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and ultimately, and most desired, Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2010).

The CK segment of the paradigm specifically refers to the base level understanding of the knowledge behind the content. This is the foundation of the TPACK model, and the other segments build upon this base of knowledge. In the teaching of the sciences, one must have a strong base of knowledge in the scientific content area of choice. This includes, but is not limited to, the latest ideas, theories, studies and concepts (Mishra & Koehler, 2006).

Given the assumption that there is a strong acquisition of knowledge in the intended area one must then fully understand how students actually learn the aforementioned information. This is where the PK segment is instituted. It has been demonstrated that students learn in a variety of ways. To work with those different learning styles educators must understand how they work and what mode students acquire knowledge in. These modes can range from Vygotsky's theory of scaffolding, a social development theory, to Piaget's development theory of learning in stages, (Atherton, 2010). An instructor must know who their students are, how they learn, and then what method of teaching would be appropriate to deliver different scientific concepts (Mishra & Koehler, 2006).

TK refers to the knowledge of technology and mandates that educators stay abreast of current technological innovations in their teaching area (Mishra & Koehler, 2015). Science educations lends itself well to this as it tends to be a rapidly evolving field, with development of new methods and tools available to educators on a regular basis. “So much of contemporary technology is based on the sciences, particularly such disciplines as physics, chemistry, biology, and other sciences that deal with the study, measurement, and understanding of natural phenomena” (Science & Technology, 2000).

Certain frameworks exist to help educators understand what technological knowledge is critical to possess to promote the effective integration of technology into their classroom(s). Educators should be steadfast in their understanding the newest trends and developments that aid in the learning of new content in science. This will allow them to both understand, and evaluate, a myriad of technologies when it comes to selection of tools for the classroom (Davies, 2011)

PCK, TCK and TPK are the combination of two knowledge areas. PCK links pedagogy and content knowledge, TCK links technology and content knowledge and TPK links technology and pedagogy (Mishra & Koehler, 2006). “The TPACK approach goes beyond seeing these three knowledge bases in isolation. On the other hand, it emphasizes the new kinds of knowledge that lie at the intersections between them” (Koehler & Mishra, 2010). The true challenge is when an instructor begins to combine knowledge concepts in order to enhance learning. However, in order to achieve a truly optimal technology enhanced learning environment, one must impeccably intermingle pedagogy, technology and content knowledge within the curriculum.

Koehler and Mishra (2010) have demonstrated that effective technology integration for pedagogy around specific subject matters requires developing sensitivity to the dynamic and transactional relationship between all three components. Halpin (1999) discovered that the integration of technology with integrated methods courses increased the probability that teachers transferred their computer skills into their classroom; as compared to preservice teachers who learned computer skills in an isolated manner.

In 2015 almost 300 educators were surveyed on their teacher preparation and education; specifically their technological pedagogical content knowledge development in regards to the technology preparation they received during their initial teacher licensure program. It was determined that the TPACK paradigm significantly impacted their learning and function of how they intend to integrate technology in their individual classrooms (Shinas, Klein, Mouza, & Glutting, 2015). The parallels between the effective use of TPACK in the classroom and student success is well demonstrated. It has been determined that this is an especially effective model to use with digital natives (Young & Hamilton, 2013).

It has been further demonstrated that TPACK is important for preservice teacher preparation, but many science education programs still do not cover it. A study done by Bilici, Guzev, and Yamak (2017) followed science education students over a semester, as their understanding of TPACK increased. They demonstrated that many programs do not include this piece of education, but did show that both pre-service teacher and their students respond positively to the method. Some researchers question if this lack of inclusion is because the model is 'too large'. Brantley-Dias & Ertmer have demonstrated that this is not a case of the model being too large, or vague, for individual educators to synthesize in their own classroom. They have found that the critical misstep that many educators take is the selection of the appropriate technology (2014). If a technology is selected that does not lend itself well to the topic, or subject, at hand it may seem like a failure of the model. However, this again demonstrates the versatility of the model and calls for greater technology knowledge.

Al-Alwidi and Alghazo (2012) showed examined the attitudes of teachers new to the field with specific focus on their attitudes towards technology integration. In this study the sample of teachers, both pre-service and educators that were new to their field, were surveyed on their openness towards novel technologies being introduced into their classroom; but in relation to their confidence in their own skills with the technology. Unsurprisingly, those educators with higher levels of confidence in their skills, coupled with a higher favorability towards new technologies, experienced higher/more positive classroom results. This has further implications for TPACK's importance when you consider the same results being demonstrated in student learners. It was demonstrated students each have difference abilities and preferences in regards to technology in the classroom. It was found that students had greater potential to use technology to facilitate their own learning when their confidence in their ability, and practical knowledge, was higher (Arena, 2015).

TPACK is over a decade old at this point and some researchers and educators began to question if the model did not age well, as certain novel technologies are now being viewed a stale or outdated. However, Cherner and Smith (2016) demonstrated that the model stands the test of time and is a robust way to incorporate new technology that students are already familiar with in their personal lives. Here TPACK was re-conceptualized to keep up with the current generation of students; who possess their own technology knowledge from an early age. In 2009 Harris & Hofer laid the groundwork for this with their discussion of activity types. They showed that TPACK can be incredibly versatile, but educators must pay specific attention to what activities they are developing for students in the classroom. In 2017 it was affirmed that the activity type selected must be appropriate to the domain of TPACK that is desired (Papanikolaou, Makri, Roussos, 2017). If an educators uses an outdated piece of technology and find lower than expected student outcomes it may appear like a failure of the model; when in reality there is a failure of the educators to select the appropriate methodology, technology, and activity. Furthermore, instructors' confidence in the TPACK paradigm was shown to improve with understanding and utilization of activity types (Hwee, 2018).

This is critical to be aware of as technological content knowledge is shown to be the area that educators struggle to stay abreast of most frequently. Hoer and Grandgennet (2012) specifically looked at the preparation teachers receive in regards to technology use. They sought to determine if these educators' knowledge and understanding of TPACK over time increased. Surprisingly, they found that the participants' technological pedagogical knowledge and technological pedagogical content knowledge showed significant increase; but only limited growth in technological content knowledge. Educationl technology courses in students' undergraduate preparation should equip preservice teachers to use TPACK and view it as a skill that can be constantly honed as new tools and methodologies become available (Hsu, 2012).

Schools, or even individual educators, may resist changes if they put pressure on existing methods of teachers (Zhao & Frank, 2003). A school system must possess a culture that supports technological innovations, and empowers educators to make those changes. Collins & Halverson (2009) have identified six main points that are crucial for technology integration. A culture that promotes new practices, a shared vision for technology use, technical support, policies to make technology available, a culture of collaboration, and assessment systems to evaluator outcomes. These six requirements line up with the domains of a student centered learning environment; specifically the cultural and pragmatic domains.

Given the potential for educators to resist technological change, researchers and educators should look at the pattern of how this integration often happens as a specific process. In 2002, Williams highlights this process: teacher incorporate technology into their current practice, next teachers notice a change in student behavior or outcomes, and then finally they experiment with ways use the technology in a novel setting. This can be viewed as a type of subtle evolutionary timeline. The cultural, pedagogy, and technological content knowledge all comingle and build upon each other; these new developments eventually become a part of a school's culture (Zhao & Frank, 2003). As these methods become part of a school system, or classroom, culture there is wider recognition of the merits of this paradigm. World-wide shifts to recognize this paradigm as a mastery of skills in areas as diverse as language acquisition are already under way (Ndongfack, 2015). With this increased recognition of the TPACK paradigm the underlying question of why there is not greater implementation of this robust paradigm remains.

SAMR

The SAMR (substitution, augmentation, modification, and redefinition) model offers a convenient framework for categorizing the types of technology being used in a classroom. The model has four broad definitions for each category. Substitution is categorized by the use of technology to replace physical resources, such as ink and paper. Augmentation keeps the assigned task the same, but enhances the task using technology. Technology is used to fundamentally change a task under the category of modification and technology allows for learning task, or assignment, that would not have been possible without the use of technology (Lydia, 2018).

The framework allows certain freedoms in the classroom, as it does not indicate that modification tasks are less worthy that redefinition, or that substitution technologies have no place in the classroom. What the model does give educators, and evaluators, is a rubric, and classification system, for evaluating how a technological tool is being used and introduced (Hartmann & Weismer, 2016). While one SAMR category may not be intrinsically more valuable than another, educators should understand that tasks falling under the redefinition category are most closely associated with student centered learning environments and proper technology integration.

SAMR, as a technology integration model and framework, gives structure to the complicated task of technology integration in the classroom. As the SAMR model has not been extensively critically analyzed in peer reviewed literature, educators often pair it with other pedagogical tools, or frameworks, when analyzing a task or learning environment (Hamilton, Rosenberg, & Akcaoglu, 2018). The model was recently found to have usefulness in various contexts when examining the ability to couple it with other models, such as the TPACK paradigm (Kimmons & Hall, 2018).

Summary

Given the current state of technology accessibility in the classroom it would be natural to assume that teacher use is on the rise; with associated positive student outcomes. Classroom activities such as instructional gaming, virtual laboratories, technological measuring devices, and novel learning environments are commonplace for today's students. Student centered learning has the promise to radically alter the way students receive information; in both mode of delivery and location of instruction.

The TPACK learning paradigm merges the promise of technology and student centered learning, while demonstrating that technology can transform how students learn in the classroom. The SAMR model offers a framework to classify and categorize the methods of technology integration being offered to enhance student centered learning.

Technology makes it possible to offer learning experiences based on a student's learning style and deliver content in previously unthinkable ways. Technology alone will not make this happen. Technology can certainly support advances in the classroom and student centered learning, however, the available literature shows that without a pragmatic approach, sound pedagogy, and solid content knowledge the implementation will fall short. Educators should be cautioned not to fault the technology if this happens, and re-examine their approach to student centered learning though the lenses of the TPACK paradigm and SAMR framework.

Chapter 3: METHODOLOGY

Introduction

The purpose of this research study was to develop an understanding of the relationship between the uses of student centered learning and instructional technology tools in the secondary science classroom, and any real or perceived barriers towards implementing them. A case study and grounded theory approach has been chosen as a design for this study. The following chapter will explain the rationale for conducting a qualitative research study and why it was the best approach for the study of the secondary science teachers selected for participation. This chapter will also explain the information needed for the study, the survey tool utilized, the case study design, data collection methods, data analysis, ethical considerations of the study, and reliability of the data.

Research Design

This study was completed using the research design of a grounded theory approach with an implemented case study. This is a specific methodology of qualitative research design that can contribute to the knowledge of an individual, or organization, in addition to the associated societies, professions, or cultures. Grounded theory methodology seeks to conceptualize an observed phenomenon, understand it, articulate theoretical claims related to it, and offer interpretation into its meaning (Charmaz, 2006). This particular study sought to examine the participants' experience teaching science using technology to create a student centered learning environment, to understand their beliefs on and understanding of these tools, and build a theory based on their experiences implementing this in a classroom. The grounded theory method often aims to explain why a course of phenomenon evolved in a specific way (Charmaz, 2006). The researcher here explored the use of and implementation of technology in the science classroom, given the increase and availability of instructional technology tools. The concluding theory is a result of the researcher's interpretation of the collected data, using a constructivist grounded theory.

To aid in the creation of this theory a case study, consisting of in person interviews and source material collection, was performed on six secondary science chemistry educators. Case studies are used in numerous fields of study including, but not limited to psychology, sociology, education, and political science. The main goal of a case study is to gather rich, and comprehensive, data that gives insight into a particular phenomenon (Yin, 2009). Case studies have the ability to shed light on current trends and issues in the social sciences, while giving the observer a keen insight into the multitude of factors that contribute to the topic being examined (McGloin, 2008).

Case studies can often be questioned if they do not follow systemic methodology, or have biased interpretation of results. Because of this, a common criticism is that case studies can be altered to fit an agenda, or specific aim, of the researcher. However, these arguments are a criticism of the researcher, and not the method itself (Willis, 2007). Case studies, as a method, are valuables tools for understanding a social phenomenon. In this study, for instance, the researcher is examining the integration of technology and student centered learning (SCL) methods in the classroom. To do this a thorough understanding is obtained, as case studies often focus deeply on a few selectively chosen subjects (Yin, 2009).

This case study used the methodology of an interview on six specific subjects. This method, interview research, uses questions to gather information, stories, and content from a subject or participant. The goal is to generalize the information found over a larger population. For this to be done, and be considered valid, it must follow a specific interview structure (Willis, 2007). This specific study is using the framework of the Nellie Mae Foundation Student Centered Learning (SCL) Questionnaire for Teachers. This was created in 2016 and is property of the Education Development Center, Inc. The survey has been used in this study with permission from the Education Development Center.

Using this framework a survey questionnaire was sent to over two hundred educators in the greater Pittsburgh and Allegheny county educational area. This survey provided descriptive data to answer the proposed research questions through examining which activities are currently taking place in the science classroom, and how educators are trained to implement them. The survey provided additional insight into educators' administrative support for implementing SCL classroom activities and their own attitudes towards technology and SCL methodology.

From those survey responses a highly structured, face to face, interview was conducted on six secondary chemistry educators. The benefit of a highly structured interview is that the researcher has no opportunity to inject their own personal bias or views into the interpretation and recording of data (Willis, 2007). The six participants, that had each completed the original survey, were chosen from public schools and a parochial school, all in the greater Pittsburgh area. A teacher was selected from each school type for two interviews. Those teachers were representative of both high and low implementers of instructional technology and SCL methodologies. This interview was structured around teacher goals, classroom environment, student to student interactions, student to teacher interactions, and administrative support.

After the initial interview to gather data a second interview was completed focusing on the five specific domains, and their associated barriers towards implementation, of a student learning environment. Hannafin & Land (1997) established the follow domains: psychological, pedagogical, technological, cultural, and pragmatic. Along with this delineation are the associated barriers. The second interview was done to determine which barriers are affecting the teachers' learning environment to the greatest extent, if any, and collect source materials from the classroom. The source materials range from instructional activities, online lecture, wiki projects, etc.

Research Questions

The study sought to build theory to answer the following research questions:

Research Question 1

What training do educators receive to implement and deliver secondary science content using technology?

Research Question 2

How prevalent is the implementation of:

- SCL in secondary science classrooms?
- Technology in the secondary science classroom?

Research Question 3

What SCL activity types are educators currently utilizing in the secondary science classroom?

Research Question 4

What instructional technology tools are educators currently utilizing in the secondary science classroom?

Setting and participants

The setting of this study was the greater Pittsburgh area, within Allegheny County. As of the last census, Allegheny County has over 1.2 million inhabitants, with over 330,000 family units. There are 45 public school districts in the county, and 17 private and parochial high schools. An additional 12 high schools exist under the umbrella of charter schools or schools for students with disabilities. Of the working population in Allegheny County, just under 6 percent of the population is employed as an educator or training professional (US Census Bureau, 2010). There was no limitation in regards to years of teaching experience or type of education degree. Participants were selected from small, medium, and large districts as well and public and private schools. The survey was sent to all secondary science teachers in these districts, as reported by their district directories.

Six participants of the original survey population were chosen for follow up interviews. They were chosen to represent high and low implementers of instructional technology and SCL methodology from a public high school and a parochial, or church affiliated, high school. This was done to determine common themes from three different areas, with the aim of producing data that can be generalized over a large population.

Data Collection

Approval for this study was sought from the Institutional Review Board (IRB) of Duquesne University. Once the researcher received approval for the study, an email was generated to the teachers, and school districts, asking them to complete the online survey based on the Nellie Mae Foundation's Student-Centered Learning Questionnaire for Teachers (Appendix A). Following the dissemination of the survey, an interview, was conducted over two sessions with six selected educators. The interview structure (Appendix B) consisted of questions relating to: demographics, pedagogy, institutional support, classroom activities, and professional development. Participants were interviewed in a private and confidential setting, and responses were kept anonymous. When given permission by the interviewees the interview questions and responses were audio recorded for transcription. Interviews were recorded on a Sony ICD-BX112 Digital Flash Voice Recorder and stored on a password protected shard drive. No interviews were conducted without written and verbal consent of the interviewee.

Each interview was then transcribed by Rev.com and compiled for examination of common themes that would reveal barriers towards implementation of instructional technologies and SCL methodology in the classroom. Transcripts were then sent to the participants for review to validate accuracy of their reported responses as a form of member checking (Carlson, 2010). This member checking was completed to establish that the data collected was valid and reflective of the subjects' true feelings and actions. Interviewees had the ability to add clarification or additional information if necessary for the study. The interviewees were not made aware of the other participant's answers or trends from the interviews, or how they compared to their peers in terms of technology integration and SCL method implementation.

Research Tool

The survey used to initially survey the greater Pittsburgh educational region was The Student-Centered Learning (SCL) Questionnaire for Teachers. This SCL survey was developed under a grant from the Education Development Center, a nonprofit agency dedicated to improving health, teaching, and education, in conjunction with the Nellie Mae Foundation. The Nellie Mae Foundation is the largest philanthropic organization in New England that focuses exclusively on education. The foundation is currently focused on increasing student centered learning practices in the classroom. This survey was created in 2016 to begin to gauge what teachers are currently doing in the classroom, that is reflective of student centered learning and instructional technology, as well as their attitudes and institutional support towards the implementation of these items. The survey launched in 2016 sought to provide large scale and generalizable data to highlight what teachers were implementing in the classroom (Nellie Mae Foundation, 2017). This research study received permission to use this tool to specifically target secondary science educators in the greater Pittsburgh and Allegheny County region. The survey was used free of cost, with the agreement that results would be reported back to the Nellie Mae Foundation.

This SCL survey was divided into 5 theme areas, which were used to guide the follow up interviews, and source materials collection, of the six selected educators. The first theme area was individual background information, to provide identifying information on the participants to allow for additional data coding. Section two asked questions related to theme areas of SCL instruction and assessment. Section three asked questions relating to theme areas of school support and collaborative culture. Section four centered on the theme of instructional practices and section five related to teachers' professional development. Each section had multiple items, based on complexity of the topic. For example, teacher ranking of total teaching time devoted to various instructional activities had 15 total sub items.

<u>Section 1</u>

1. School identification
2. Subjects taught
3. Gender
4. Race/Ethnicity

5. Years taught

6. Grade level(s) taught

<u>Section 2</u>

7. Teacher rating of personal involvement in efforts to enhance SCL

8. Teacher rating of impact on instruction

9. Teacher rating of impact on student engagement and college and career readiness

10. Teacher rating of impact on what/when/where/and from whom students learned

11. Teacher rating of preparation to support student learning that requires:

- Collaboration
- Personalization
- Critical Thinking or Problem Solving
- Student Self-regulation and Academic Tenacity
- Anytime/Anywhere Learning

12. Teacher rating of frequency of instruction that requires:

- Collaboration
- Personalization
- Critical Thinking or Problem Solving
- Student Self-regulation and Academic Tenacity
- Anytime/Anywhere Learning

13. Teacher ranking of importance of various assessment methods

<u>Section 3</u>

14. Teacher rating of school support for various student-centered practices

15. Teacher rating of practices that foster collaborative culture

<u>Section 4</u>

16. Teacher ranking of importance of various instructional activities

17. Teacher ranking of total teaching time devoted to various instructional activities

18. Teacher rating of frequency of various student learning activities

<u>Section 5</u>

19. Teacher attitudes about their professional development

20. Teacher professional development experiences

Data Analysis

The results of the implementation of the Nellie Mae Foundation survey were compiled to form aggregate descriptive data. Much of the data collected fell under the category of descriptive identifiers, such as years teaching or subjects taught. Answers were quantified and separated with respect to school type (public, private, or parochial). Common trends and findings were identified in each of the groupings.

From the identified data six participants were selected for follow up interviews. High implementers and low implementers of instructional technology and SCL methodology were selected for further interviewing on their classroom methods and experiences. The interview transcripts were then carefully coded for common themes, using the N-Vivo 12 software package. Common themes were extracted to group data that gives insight into the established research questions of the study. The analysis done on the collected data was content analysis, a method of coding data to answer a research question by identifying themes that answer selected research questions (Charmaz, 2006). Content analysis allows the researcher to uncover both apparent and underlying themes in a given set of data. This allows the researcher to make conclusions based on the frequency key terms are used, to test a given hypothesis, and conduct thorough screening of the data (Charmaz, 2006). In this case, themes were collected by coding answers that relate to teacher training, implementation of SCL and technology, SCL activity types, and instructional technology tools.

In vivo coding was used to reduce and classify the collected data so that the common themes, and trends, of the data can be determined. This method is preferred as it uses participants' exact language to generate codes and maintains the participant's exact language and terminology. This method is favored due to its ability to limit focus and prioritize the viewpoint of the individual participant (Strauss, 1987).

Once codes for the data were established patterns and relationships between codes are identified. Categorizing was then done to group similar, or seemingly related, codes together. As the coded data was evaluated it was divided in common themes.

The following typological and interpretive analyses were employed, based on the framework established by Hatch (2002).

1. Review the data for a sense of the whole (Interpretive)
2. Review entries and sort by research questions, recording the main ideas or impressions (Typological and Interpretive)
3. Look for patterns, themes, and relationships by typologies (Typological)
4. Review data, coding places where interpretations are supported or challenged and identifying patterns and themes (Typological and Interpretive)

5. Look for relationships among the patterns and themes identified (Typological)

6. Write a draft summary (Interpretive)

7. Review interpretations with peer debriefing (Interpretive)

8. Write a revised summary and identify excerpts that support interpretations (Interpretive)

The established frameworks of SAMR and TPACK were then used to categorize and quantify the activities taking place in each teacher's classroom. The technology tools being used in the classroom were divided in the four distinct domains of the SAMR Model: Substitution, Augmentation, Modification, and Redefinition. To further understand the complexity of relationship between students, teachers, content, classroom practices, and instructional technologies the TPACK paradigm was used to determine if the selected teachers are exhibiting true technological pedagogical content knowledge.

The quantified, coded, and evaluated data was then compiled and compared against the five known barriers (psychological, pedagogical, technological, cultural, and pragmatic) that can inhibit the implementation of a student centered learning environment. Using these segments of information the research questions were evaluated in relationship to the collected data to generalize the experience, and challenges, of implementing a student centered learning environment.

Ethical Considerations

Participants voluntarily took part in this study, and were entered into a random drawing for six Amazon.com giftcards. Each participant signed a formed given their informed consent to be a part of this study. Participants were advised of their rights to privacy and anonymity. Participants were able to view their transcripts of the conducted interview, as well as a copy of the final study. No participants were privy to the answer of other participants, the school district the participants were from, or any other data that could be used to determine the identity of the other participants. As the information collected was highly detailed, and could have had the potential to reveal negative aspects of the participants' place of employment, or associated school district, the utmost care and concern was given to respect their anonymity for the free exchange of ideas.

Limitations of the Study

Every effort was taken to reduce the apparent limitations of the study, and the associated design. As the researcher is currently employed at a university with many students coming from the selected districts there could have an internal bias towards the participants. To nullify that full disclosure was employed on behalf of the researcher to be upfront about any potential subjectivity.

Additionally, the scope of the study, a single case study approach, does limit the generalizability of the data to districts, and teachers, outside of the region. The depth of the data collected is only possible due to the narrow scope of the population sampled. The goal of this study was to examine the experience, specifically of chemistry, science educators, so that the data could be applied to the natural and environmental sciences as a whole with further research and evaluation.

Summary

This previous chapter outlines this study's research questions, methodology, survey instrument, methods of analysis, ethical considerations, and potential limitations. As chapter two has demonstrated, much care and concern has been given to student centered learning as a whole, and there is significant research centered on instructional technology and its associated integration in the classroom. However, specific studies have not looked to address the environment specifically within science classrooms. This study sought to give data so that the delivery science in the secondary education classroom can be more reflective of a student centered learning environment that exhibits technological pedagogical content knowledge on behalf of the educator.

Chapter 4: RESULTS

This chapter contains the results of the grounded theory methodology study conducted to answer the following research questions (RQ):

(R1): What training do educators receive to implement and deliver secondary science content using technology?

(R2): How prevalent is the implementation of:

- Student Centered Learning (SCL) in secondary science classrooms?
- Technology in the secondary science classroom?

(R3): What SCL activity types are educators currently utilizing in the secondary science classroom?

(R4): What instructional technology tools are educators currently utilizing in the secondary science classroom?

This chapter also includes the analysis conducted, which was consistent with grounded theory methodology, and how the analysis ties back to the four stated research questions. This chapter will also include sample demographics in summary form to better describe and understand the sample studied. The process used to analyze transcripts from the six individual interviews conducted to determine common and recurring themes, or patterns, is outlined in this chapter. Typographical and interpretive analyses will be showed based on a review of the data, patterns, themes and relationships. The survey and interview responses will then be examined through the lenses of the TPACK and SAMR frameworks introduced in chapter one. These frameworks, themes, and trends will then be compared against five known barriers of implementing a student centered learning environment; psychological, pedagogical, technological, cultural, and pragmatic (Hannafin and Land, 1997).

Sample and demographics

This study began with an initial survey sent to secondary science teachers in the Allegheny County school districts, based on school district directory information. From this initial inquiry, and follow up reminder, 51 teachers voluntarily selected to fill out a 19 question survey. The highest percent of respondents taught biology (27.45%), chemistry (23.52%), and physics (15.69%). Many of the respondents also taught engineering, math, or a combination of science courses based on the size of the district and enrollment of their school. A range of experience teaching was desired, and found, in the respondents of the survey. From the sample the majority of respondents were teaching for 11-20 years (43.14%), a smaller sample had been teaching for over 20 years (29.41%), six to ten years' experience was the next highest amount (23.53%), and finally the smallest amount was found in two to five years' experience (3.92%). Interestingly, none of the respondents were in their first year of teaching. A fairly even distribution of classroom levels were found in this respondent sample: six to eight grade (13.73%), ninth grade (21.57%), tenth grade (19.61%), eleventh grade (23.53%), and twelfth grade (21.57%). Compiled demographic data can be seen in Table 4.1 below.

Table 4.1
Demographics of initial survey respondents

Classes Taught	Years Teaching	Primary Grade Level
Biology (27.45%)	11-20 (43.14%)	11th (23.53%)
Chemistry (23.52%)	20+ (29.41%)	12th (21.57%)
Physics (15.69%)	6-10 (23.53%)	10th (19.61%)
Health Science (3.92%)	2-5 (3.92%)	9th (21.57 %)
Other/multiple (19.61%)	1 (0%)	6-8th (13.73%)

Table 4.1

Many respondents noted that they selected their primary teaching responsibilities, but often teach other class levels as the quarters, or semesters, change. One respondent was currently teaching ninth grade algebra, but would be teaching tenth grade biology in the winter semester. From these respondents six were selected for further interview and data collection. From this sample two teachers taught over 11 years, two teachers taught six to ten years, and two teachers taught 2-5 years. All teachers were self-reported to be supportive of technology use in the classroom, with varying use and implementation. Three of the respondents (1, 2, 3) would be classified as high adopters of instructional technology and three (4, 5, 6) would be classified as low users of instructional technology. This determination was made based on their self-reported answers to questions 10, 11, 12, 18, and confirmed by their reported uses and response to follow up interview questions. The six interview respondents taught a range of subjects including physics, chemistry, health sciences, general science inquiry, and biology. Summary demographics can be found below in Table 4.2.

Table 4.2
Demographics of initial survey respondents

Classes Taught	Years Teaching	Primary Grade Level
Biology (27.45%)	11-20 (43.14%)	11th (23.53%)
Chemistry (23.52%)	20+ (29.41%)	12th (21.57%)
Physics (15.69%)	6-10 (23.53%)	10th (19.61%)
Health Science (3.92%)	2-5 (3.92%)	9th (21.57 %)
Other/multiple (19.61%)	1 (0%)	6-8th (13.73%)

Table 4.2

Data Collection

The primary source of data in this study was the initial 19 question survey (appendix A). The survey tool consisted of questions on basic demographic information, teaching style, technology integration, and classroom set up. From this sample of 51 teachers a select group of six were chosen for interview. A preliminary meeting was held with each of the interviewees to go over the goals of study, confidentiality and anonymity of the respondents, and to answer any questions the participants may have had. After the initial meeting an interview was held to gather deeper information on the interviewees teaching style, technology integration, and activity types utilized in the classroom. These interviews were then transcribed and manually coded for themes (appendix D-I). These transcribed interviews were sent to the respondents to insure accuracy of transcription and data, and to allow for any additional clarification. Respondents were then asked if they were comfortable sharing examples of classroom activities the mentioned in the classroom. Not all respondents felt comfortable sharing materials they had created, or which were the property of their districts.

Data and Research Questions

Research Question 1

Research question one was centered on the training the educators receive to either implement technology in the classroom or deliver science content using technology.

Survey Results. From the initial survey it was clear that minimal technology training was given to the majority of teachers surveyed. Of this sample, 63.79% of teachers reported that they were not prepared to deliver student centered learning in a way that requires personalization or student choice in their work. Similarly, 50% of teachers responding felt that they were not prepared to provide virtual learning, or any of the associated tasks (flipped classrooms, learning from home, etc.). From this sample 32% felt adequately prepared to do this, while only 18% felt very well prepared. The survey did not ask what the source of their preparation was. In the survey it was found that only 40.48% of teachers felt that their teachers and districts had a shared vision of effective instruction, which may point to a divide between district initiatives and classroom practices of the survey respondents.

Interview Results. All six interview subjects reported no training in instructional technology or the pedagogical background to deliver their science content using technology, as seen in Table 4.3. A recurring theme was "learning as I go". This phrase or sentiment appeared in all six interviews. All respondents reported learning many of their tools and practices from other teachers in their district, or an instructional technology support person. Teacher 5 specifically says, "I picked up a lot just by watching what my mentor did. I don't think I learned it at all from my school of education, to be honest with you. I think I learned it from the science professors I had, just watching them." This finding is supported by the initial survey which shows that over fifty percent of teachers found their district community environments to be supportive, with the ability to learn from other teachers and share strategies (question 14).

When comparing high implementers of technology with low implementers of technology no trend was found in regards to years taught, subject taught, or grade level taught. No trends were found in terms of training received, as no teacher had formal educational training. Furthermore, no trend was found in regards to district in-service trainings offered.

Table 4.3
Self-reported levels of technology training

Teacher	BS/MS Coursework	District In-services	On Going Training	Technology Support if Needed	Technology Use
1	None	No	No	Yes	Low
2	None	Yes	No	Yes	Low
3	None	No	No	Yes	Low
4	None	Yes	No	Yes	High
5	None	Yes	No	Yes	High
6	None	Yes	No	Yes	High

Table 4.3

Each interview subject reported their classroom, or district, to have a one to one ratio of student to technology. Half of the respondents utilized iPad technology and half utilized Google Chromebook. These tools were selected by the districts and given to the teachers without feedback or training. One of the respondent teachers reported only using the Chromebook to allow students to check e-mail and take tests, as they felt there was no time to train themselves on new instructional tools or methods.

Research Question 2

Research question two centers around the prevalence of student centered learning instruction in the classroom and the use of technology in the classroom. Based on the interviews and initial survey it is clear student centered learning is valued and used in the secondary science classroom. Self-regulation, critical thinking, problem solving, and collaboration were the most prevalent means of delivering content using SCL strategies.

Survey Results. Teachers reported at a rate of over 70% that their school districts were supportive of this (survey question 13). The respondents reported that most important aspects of SCL in their classrooms were: modifying their classroom instruction based on student feedback and performance, promoting engagement with open ended discussion questions, and giving students individualized feedback on their work.

Table 4.4
In your classroom over the past year, how often did you provide instruction that:

	Never	Occasionally	Often	All the time
Requires collaboration	2.17%	10.87%	47.83%	39.13%
Requires personalization	4.65%	48.84%	37.21%	9.30%
Requires critical thinking/problem solving	0.00%	8.51%	36.17%	55.32%
Requires academic tenacity/self-regulation	2.04%	22.45%	40.82%	34.69%
Requires any-time learning	24.00%	34.00%	32.00%	10.00%

Table 4.4

Only 22% of teachers felt that instructional technology was the most important aspect of delivering content in their classrooms, with 45.67% of teachers reporting that technology was not important to their efforts to deliver SCL in their classroom (question 15). It was determined that most prevalent ways teacher deliver this content was through classroom investigations with problem solving and complex reasoning (55.17%), followed by asking open ended questions to promote engagement (44.44%), and having students explore alternative methods for solving problems (40%). The individual interviews supported these findings, with all respondents believe that their classrooms support SCL, individualized assessment, and a variety of learning objectives.

Interview Results. Technology was found to be present in the secondary science classroom of each interview subject, with varying degrees of use. From the survey, no classroom was found to have zero use of instructional technology. The use of an online course management system was found to be the most frequent tool used daily, following by internet applications, and electronic mail communications. Tools to promote distance, or any time learning, were found to be the lowest used tools, followed by wiki spaces, or virtual collaboration spaces. All interviewed teachers reported using technology to deliver assessment, text materials, and present data and findings. Only two of the six teachers interviewed have used a virtual laboratory or laboratory simulation to enhance student learning. Half of the teachers responded that they do use instructional applications or games to enhance student learning outside of the classroom, but do not require the use. It was found to be offered as a supplemental tool if students want to expand their understanding of a topic.

Student centered learning was found to be present in every classroom of the six interviewed teachers. Each teacher made a direct reference to their student being the driver of the classroom activity, daily checks for understanding, alternative modes of delivery for instruction, and collaborative or investigate work in groups. Teacher one specifically said, “I want my students to feel empowered in the classroom. I can provide a couple ideas to start out the day and then kind of get a flow, get a flow of knowledge going. Some curiosity asking the right questions in a classroom is very important.” Teacher six echoed these sentiments, “There’s a lot of information students want to share and already know, so it’s very, very, important that it’s not just the educator fulfilling knowledge. I don’t want to be the only one just talking in the room.” Table 4.5 highlights some of the main thoughts each teacher offered on SCL in their classroom.

As seen, use of SCL was not found to be related to years of teaching or training on technology use in the classroom.

Table 4.5
SCL evidence in survey respondents' classroom

Teacher	Years Teaching	SCL Implementation	Comments on SCL
1	11 - 20	High	You're kind of laying the groundwork, but the next day its discovery and understanding from the student perspective, rather than guiding the instruction.
2	6 - 10	High	They're obviously constructing their own knowledge and coming up with things on their own.
3	2 - 5	High	75% of my class is group work, lab work, examples, group exercises, or real world applications based learning.
4	2 - 5	High	In my own classroom I try to get them synthesizing their own knowledge and taking the basics to the next level. I only do about 10 - 15 minutes of lecturing. The rest is guided practice and group work.
5	11 - 20	High	We'll have discussion, go over information, and then we" do an activity. I'll walk around and answer questions. It's a mix of things going on.
6	6 - 10	High	I think again it comes to the idea that if I'm talking I'm gathering a lot of student feedback. If it's this formative assessment, like we're talking about, did you understand that, can we really put that into application? And then working in small groups depending on what the process looks like and the activity I need to accomplish.

Table 4.5

Research Question 3

Research question three centered on the SCL activity types that educators are currently utilizing in the secondary science classroom.

Survey results. The most common activities types were found to be student portfolios, classroom discussion, extended projects, and class projects that require collaboration. Lab notebooks and student presentations were also considered important and intrinsic to the delivery of science in the classroom. SCL activity types were found to be frequently used in the classroom. No respondent reported having a classroom environment where SCL methodology was not employed in at least one way. No single SCL activity type was reported to have daily use. The single highest activity type used daily was found to be the use of students working together in small groups (44.68%). A summary of thirteen commonly accepted means of delivering SCL can be found, along with the frequency of use, in figure 4.6.

Table 4.6

How often have students engaged in the following types of activities during this school year?

	Never	Rarely	Sometimes	Often	Everyday
Participate student-led discussions or activities	8.89%	17.78%	44.44%	20.00%	8.89%
Participate in discussions led by the teacher	2.13%	2.13%	34.04%	44.68%	17.02%
Listen to teacher presentation/lecture	0.00%	15.22%	32.61%	39.13%	13.04%
Make formal presentations to the class	18.60%	34.88%	30.23%	13.95%	2.33%
Work together in pairs or small groups on an assigned task	0.00%	0.00%	8.33%	45.83%	45.83%
Work individually on an assigned task	0.00%	7.14%	35.71%	40.48%	16.67%
Explain their reasoning or defend a position orally or in writing	6.52%	13.04%	28.26%	30.43%	21.74%
Answer textbook/worksheet questions	4.65%	20.93%	27.91%	39.53%	6.98%
Design or implement their own investigations or research projects	11.36%	29.55%	36.36%	18.18%	4.55%
Write reflections	14.29%	30.95%	30.95%	19.05%	4.76%
Work on solving a real-world problem or conducting hands-on experiments	6.82%	11.36%	15.91%	45.45%	20.45%
Work on materials for a portfolio	65.96%	10.64%	14.89%	6.38%	2.13%
Engage in performance assessments involving teachers and peers	13.04%	30.43%	36.96%	15.22%	4.35%

Table 4.6

Interview results. All interview subjects reported that they used different activity types based on the content, or class size, at hand that were characteristic of a SCL environment. Table 4.7 outlines some of the main activities the interview sample of teachers were using. Teachers four and five were found to have the most use of SCL in their classroom, and were also two of the three highest implementers of technology in the classroom. This trend was not found to be related to the years of experience teaching found in each interview subject. Teachers four, five, and six have taught for 2-5 years, 11-20 years, and 6-10 years, respectively. Teacher two outlined a best practice for a semester end project characteristic of SCL, “Well, they work on their big project and like a second portion of my class. I give them some ideas, because it's a really big project and it requires a lot of research. They will then make a PowerPoint, and they have to present for 20 minutes. They have to write a research paper and they have to create like a quiz or a handout for their classmates. I show them previous work that did phenomenal, pretty much, on that project to give you an idea like hey, this is what I'm looking for. This is what it looks like. This is how it should be set up like here in an example, like an exemplary student from previous years or previous semesters, you know, and this is exactly what I'm looking for.”

Table 4.7
Main SCL Activities Used in Interview Subjects

Teacher	Group Work	Research Projects	Real World Problem Solving	Portfolios	Concept Checks
1	X		X		X
2	X	X			X
3	X		X		X
4	X	X	X	X	X
5	X	X	X	X	X
6	X		X	X	X

Table 4.7

Research Question 4

Research question four centered on the instructional technology tools that educators are currently utilizing in the secondary science classroom.

Survey Results. The most commonly used tool was Google classroom, even when utilizing Apple technology. This course management system was most frequently used to deliver feedback, communication, and assessment of student work. The second tools utilized daily were electronic books, or course materials. Most teachers reported that internet applications were offered as supplemental instruction with their electronic texts. Traditional forms of classroom technology such as PowerPoint, YouTube, and Excel were used frequently in additional to application based technologies. The common tools teachers are using in the classroom can be found in table 4.8.

Table 4.8
Which instructional technology tools do you use in the classroom, if any?

	Never	Occasionally	Daily
E-mail communications	7.84%	37.25%	54.90%
Message boards/wiki spaces	47.92%	27.08%	25.00%
Course management software (blackboard, moodle, etc.)	15.69%	11.76%	72.55%
Phones/Tablet apps	26.00%	44.00%	30.00%
Computer software	12.24%	48.98%	38.78%
Internet	0.00%	31.37%	68.63%
Distance learning/video capture tools	51.02%	40.82%	8.16%
Multimedia platforms (Share videos/movies/recordings)	14.00%	68.00%	18.00%

Table 4.8

Interview Results. Half of the teachers (2, 4, and 6) interviewed reported use of Quizlet and Kahoot! software. Kahoot! is a mobile application that allows for instructional gaming and a variety of assessment tools. Quizlet is mobile and web-based study application that allows students to study information via learning tools and games. The most common use of this was the interactive flashcard feature, which allows for dynamic feedback on which content areas students are either excelling on or need to work on. Only two teachers (4, 5) were found to use virtual labs or simulations to help students carry out experiments and do original research. These results were not found to be related to years of teaching, but were found to both in the biology classroom.

Teacher 4 outlined a SCL use of technology in their classroom, “I think that they have worked individual and collaboratively in technology to form hypotheses and things like that. Now on the other side of the virtual lab, we've done like karyotyping where they had to figure out a patient X, what chromosome abnormality do they have based on the karyotype. I don't tell them. It's open ended, and then beyond that they would tell me the causes and the mute gens that could have caused the chromosomal abnormality. That's just something that popped into my head is something that we did with technology, but they work collaboratively. It was open ended, they took it to where they wanted to take it. We did some cancer research too on rogue cell division and the cell cycle using a virtual lab.”

Table 4.9
Technology Tools Used in Interview Subjects

Teacher	Google Classroom	E-mail/ File Sharing	Flipped Classroom	Virtual Labs	E-Books	Apps
1	X	X				
2	X	X			X	X
3	X	X			X	
4	X	X	X	X	X	X
5	X	X		X	X	X
6	X	X				

Table 4.9

SAMR Analysis

The SAMR (substitution, augmentation, modification, and redefinition) model offers a system for categorizing the types of technology teachers are using in the classroom (Puentedure, 2012). The majority of the teachers surveyed were using technology to substitute or augment student learning, rather than modify a task or redefine the task at hand, as seen in figure 4.10.

Table 4.10
Number of SAMR associated technology tools used

Teacher	Substitution	Augmentation	Modification	Redefinition
1	3	3		
2	6	4		
3	4	5		
4	4	4	1	1
5	6	3	1	1
6	4	4		

Figure 4.10

Of the teachers interviewed only two were using technology to offer a task that would not be possible to do without the instructional technology tool at hand. Each of those were found in the biology classroom. One example, utilized by teacher five, was a genetics lesson where students could raise, breed, and categorize flies to better understand the principles of genotypes and phenotypes. This experiment can be done in person, and may seem like a substitution use of technology at first glance. What made this experiment a redefinition task was the ability share and manipulate data, use dangerous chemicals students would not access to otherwise, and edit environmental factors that cannot be controlled in real time data collection.

The second example of a redefinition task found was the use of a virtual karyotyping tool in the biology classroom, used by teacher four. Karyotypes are a method of examining and categorizing human chromosomes. Students could theoretically do this without any technology in the classroom, by cutting and pasting with paper and glue. The example found in this study was a virtual setting that allowed students to zoom in and examine the chromosomes at a level not possible on paper. Additionally chromosomes were able to be edited and shift to display various genetic conditions. The teacher then used technology to tie in real world examples of these conditions and genetic topics found in current events.

Modification tasks were found in teachers four and five, as well. Teacher five described a modification task where students created dynamic lab reports, instead of a traditional written paper. This was able to incorporate results and findings from groups, import multimedia, and present data in way not possible on paper.

Augmentation tasks were found in every teacher, with the most being used in teacher three. These tasks use technology to provide a direct substitute for a traditional format, with a function improvement. An example common to every teacher was a PowerPoint presentation, using text, media, and created data displays.

Substitution tasks were found in every teacher, with the most being used in teachers two and five. No relationship was found between these teachers years of teaching, subject taught, or technology use, as each represented a high and low adopter of technology.

TPACK Paradigm

The Technological Pedagogical Content Knowledge (TPACK) paradigm gives this study a framework to determine which knowledge types teachers possess, and what areas might be lacking that would ultimately lead to technology integration not successfully taking place in the classroom. This paradigm is critical to evaluate the six interview subjects with, as each had available technology and a desire to use it in their classroom. There are three different knowledge bases in TPACK that intersect and can be applied to the classroom. Those knowledge areas include: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK). These three types of knowledge can intersect to give: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and ultimately, and most desired, Technological Pedagogical Content Knowledge (TPACK) (Mishra and Koehler, 2006).

All teachers were found to have knowledge of pedagogy, technology to certain extents, and their specific scientific content. All six teachers spoke highly of their training to deliver science content and their ability to deliver science instruction. Each teacher was found to have pedagogical content knowledge based on self-reports (PCK). No teacher interviewed expressed difficulty with their subject area and felt that they were able to effectively communicate their selected topics to their students.

Progressing thought the TPACK paradigm, Technological Content Knowledge (TCK) was found in five out of the six teachers based on information given in the individual interviews. Those five teachers all felt that they were aware of instructional technology, or basic technology, to varying extents. Teacher one explicitly reported not have TCK. When asked if they knew of technology tools to use for different subject they responded, “No. I would have to take my own time to learn that.”

Only two of the teachers (4, 5) were found to have Technological Pedagogical Knowledge (TPK). This was determined from their high use of modification and redefinition tasks of the SAMR model and their frequency of technology use in the classroom. The chromosomal and genetic examples given from those teachers highlight their TPK, as it would not be possible to deliver such content without it. Teach 4 spoke of using Google classroom for more than a grade book for file sharing device and said, “if they miss a lab they can go online and look up images of what we did and make up pieces so they don’t get behind.”

While all six were using technology in the classroom, only two had the knowledge base that came from the intersection of instructional technology and how to use it to deliver science in their classroom. Finally, only two teachers (4,5) were found to have true technological pedagogical content knowledge. This can be seen in their use of modification and redefinition tasks, as well as knowledge of how and when to use different technology tools to achieve different course objectives. It is important to note that neither teacher was trained in this, but sought out the knowledge and acquired it through trial and error in the classroom. Teacher five shared, “You have to be careful though. It’s [technology] a really important resource. There has to be a lot of check and balances in place.” This sentiment shows true TPACK as the teacher is speaking of not just relying on technology to teach a lesson, rather using proper technology that is appropriate for the content and pedagogy at hand.

Table 4.11
TPACK Knowledge Areas Observed in interviews

Teacher	PCK	TCK	TPK	TPACK
1	X			
2	X	X		
3	X	X		
4	X	X	X	X
5	X	X	X	X
6	X	X		

Table 4.11

Table 4.12
TPACK Activity Types Observed in Interviews

Teacher	1-5	5-10	10-15	15-20
1		X		
2			X	
3			X	
4				X
5				X
6			X	

Table 4.12

Case analysis

When looking at the six teachers interviewed, several pieces of data come together to offer two distinct cases found. This data includes survey responses, interviews, and source materials from the teachers themselves. The two cases that emerge are characterized by grouping of the four teachers without comprehensive TPACK, and the two teachers with TPACK.

As the first case of teachers is examined, those with TPACK, a few common characteristics emerge that highlights the commonalities between these two teachers. These two teachers worked in different districts, had different levels of education, and went to different colleges for their teacher preparations. However, they both were found to be high implementers of technology and SCL while teaching biology. While both of their districts offered in-services on training, each district only had one person available to them for technology support.

These two teachers in this case were the only teachers that exhibited TPK, and therefore TPACK. Given that they possessed the most areas of knowledge in the TPACK paradigm, it is not surprising that they also exhibited the most TPACK activities. These two teachers appeared to be the most reflective about their teaching practices and both engaged in periodic assessment of their teaching. Teacher five highlighted this best, “That's the honest truth I have about being a good teacher, it's really by working with other really good teachers and being able to work with them, and then reflect with them on, you know, what are some good ideas with what I did in the class, bad ideas and go from there.” Teacher four offered similar thoughts on assessing their own work, “I'm also trained in administration, so I'm a very data oriented. I really, really look at the previous year test scores.” Both teachers used formal and informal means of assessment to determine if their classroom practices were working and then had the ability to alter them to meet their needs. This is reflective in their pedagogical knowledge and TPK.

This is further highlighted in each of these teachers reporting that they make their own classroom materials. Teacher five reports, “I make all my own resources. I don't use the textbook much. Kids in general are reluctant to actually go to the book. I use it as a resource, but I use and create all my own materials. And it's based on experience. What I know works or doesn't work." Teacher four echoed these sentiments with their creating of their own textbook, "It's a free resource and we adjust it. We kind of arrange the chapters in the order that we teach the topics and we can link the topics and add details and add vocab words, kind of just a mash up and pacing of our own classroom. And we can adjust the textbook to our own classroom and cater it to how we teach."

These two teachers both exhibit high levels of motivation to teach themselves technology, and have the ability to assess their practices to alter the needs of their students and classroom. It cannot be definitively stated that biology lends itself better to these practices, but is a commonality shared between these teachers. While these teachers did not receive formal training they exhibited no fear of testing new technologies in their classroom, and working with the task at hand until it was successful for their classroom. A high level of tenacity and confidence in their teaching ability and content knowledge was a hallmark of these two teachers.

Figure 4.13
Case 1: Teachers with TPACK

Teacher	TPACK Activity Types Observed	SA Activities	MR Activities	SCL Use	Years Teaching	Tech Use	District In-services	Class
4	15-20	8	2	High	2-5	High	Yes	Biology
5	15-20	9	2	High	5-10	High	Yes	Biology

Figure 4.13

In contrast to the first group of teachers would be case 2, the teachers without full TPACK. All of these teachers were found to be missing technological pedagogical knowledge, and therefore complete TPACK. Four out of the six interviewed teachers were in this group and shared many common traits.

From this group, a range of years teaching was observed with a consistently high use of SCL activities in the classroom. None of these teachers used technology tasks represented by the upper end of SAMR, both modification and redefinition. This is reasonable, as they were missing TPK and likely did not have the knowledge to offer tasks that were redefined and modified based on the technology at hand. These teachers were all using 5-15 activity types, as categorized from the TPACK paradigm.

Half of the teachers had district in-services offered on technology training and half did not. These teachers were using technology mostly in the areas of grading systems, e-mail, and electronic tests, which is seen in their substitution and augmentation uses of technology.

None of these teachers had heard of the TPACK paradigm before and did not outright articulate their lack of TPK, but offered several statements that hinted at this when asked about possessing TPK. When outright asked if teacher possessed this pedagogical knowledge they responded, "No, I would have to I would have to take my own time to learn about it."

A common theme to this case was that these teachers, for the most part, felt that they were all high implementers of technology. When asked about their use all of the teachers responded that they used technology frequently, and considered themselves to be high users, when only one teacher truly proved to be using technology at a high frequency. When asked what technology was being used, and how frequently, teacher 2 responded, "I would say that it's integrated in pretty much all of them [lessons] because I'm, you know, if I'm lecturing I'm doing a PowerPoint each day." This use of PowerPoint is certainly worthwhile, but does not exhibit true TPACK. This group felt that they were using technology frequently, but did not possess the

TPK to understand that the technology they were utilizing was at the lower end of SAMR and was not optimizing the technology to the fullest potential.

Figure 4.14
Case 2: Teachers without TPACK

Teacher	TPACK Activity Types Observed	SA Activities	MR Activities	SCL Use	Years Teaching	Tech Use	District In-services	Class
1	5-10	6	0	High	11-20	Low	No	Biology
2	10-15	10	0	High	6-10	Low	Yes	Health
3	10-15	9	0	High	2-6	Low	No	Physics
6	10-15	8	0	High	6-10	High	Yes	Chemistry

Table 4.14

Typographical and interpretive analyses

To determine the major themes or recurring patterns of the collected and analyzed data typological and interpretive analyses were employed. Results are presented according to a word cloud analysis and determination of common codes and themes. The first step of this analysis was to review the data to determine a sense of the finds. Basic common themes began to emerge from this analysis.

Word clouds. To aid in this process a word cloud analysis was performed on the interview responses from all six teachers. Figures 4.1 and 4.2 highlight the difference between teacher one and teacher five. These teachers were selected for initial analysis as they have the same experience teaching (11-20 years), amount of technology training (none), high use of SCL in the classroom, and represent both levels of technology use (low and high). Teacher one was using technology at the substitution and augmentation categories of SAMR, while teacher five was offering tasks that truly modify and redefined the tasks at hand.

Teacher five referred to their pupils as ‘kids’, while teacher one used the terms ‘students’. In both word clouds it is event that the students are the focus of the classroom, and not the teacher. Words like communicate, activities, individual, and question appear most frequently in both clouds. This is consistent with the findings that SCL methodology is valued and employed in all of the classrooms interviewed, especially teachers one and five.

As expected, only teacher five’s cloud show frequent use of terms like iPads or computer. This is consistent with findings that show that teacher five was using technology at a higher level than teacher one.

Figure 4.1. A word cloud based on teacher one’s interview responses.

Figure 4.2. A word cloud based on teacher five's interview responses.

Themes. Three major themes were found in both the original survey and the follow up interviews. Those themes were: 1) positive views of technology with no pedagogical training, 2) favorable views of SCL with daily classroom integration, 3) and lack of district or administrative support.

The first theme was a positive view of technology with no associated pedagogical training on its implementation. This can be seen in the lack of TPK, from the TPACK paradigm, observed in the interviews. Support for this theme can be particularly identified in survey question 16 and 18. These questions show that the most common uses of technology were e-mail communication, course management software, and computer software. When asked how these tools were used the answers relied heavily on substitutive and augmented forms of technology integration, per the SAMR model. Only three teachers of the original survey sample felt that technology to personalize instruction or offer the technology in a modification and redefinition manner were critical to their classroom instruction. Underlying this theme was that idea that there was not enough time in the day, or week, to take on learning new technology for use in the classroom. One teacher said, “I have the calculators to program, but to have the robots to program I think would be a great component to a STEM environment and I think that would be something great to research and look into and speak with other districts that do that, but the time and effort is not necessarily there. I would have to take my own personal work time to go and do that, or my evenings, or my weekends. I would have to take my own time to learn about it.” Teacher two echoed those sentiments, “there are times where I feel like I do have to like breeze through and like just lecture and get through, and then review and test. I feel like I don't have time to do other things that I would like to do, or expand or projects on other things because there's so little time.”

None of the teachers reported any pedagogical training to implement technology and most reported that their district only had one person to assist in that effort. Teacher five highlighted this, “we do have a tech person where I teach, but we have one person who is responsible for 1500 students, plus one hundred faculty. So, it’s sometimes difficult to reach out and get the support you need. And that’s why a lot of the time you are on your own to utilize technology.”

The second theme was an overarching favorable view of SCL, which included daily classroom integration and use. When looking at survey question 11 it was clear that there was daily use of collaboration, personalization, critical thinking or problem solving, self-regulation, and even any-time learning. No respondent reported that they had a class that was absent of at least one of these activities types on a daily basis, meaning at least one form of SCL is used daily in each of the classrooms of the 51 respondent teachers. This is supported by survey question ten, which shows that teachers feel prepared to offer these forms of instruction. Each of the six interview respondents had favorable things to report about SCL in their classroom, ranging from its value to ease of use and adaptability. Many of the teachers felt that direct instruction, indicative of teacher center learning, did not meet their educational goals. Teacher six reported, "Like, what do they know about, what do they know? I think that's your first step. I think you really have to work on the idea there is the connection to what you're accomplishing, what you're trying to accomplish, circularly what do you consider your level of mastery, what do you need them to accomplish and what are you going to accomplish overall. Direct instruction is not always going to meet your needs, nor do I think it's always the most effective choice. So, I see my classroom as a mix of all different types of features." No interview respondent reported that they spend over 50% of the classroom time lecturing or offering direct instruction in that manner. Teacher three reported that, "25% of class could be categorized as note taking in response to my lecture, the other portion of class is characterized by group work, lab work, examples, group exercises, or real world applications based learning."

Teacher one echoed these sentiments in their classroom style, "topics that perhaps are taught over 3 or 4 days where the first day you're kind of laying the groundwork, but the next couple of days it's more discovery and understanding from the student perspective, rather than guiding the instruction. It is so important. If there's one thing I've learned in 10 years, it's that there's, you know, you have 25 students learn 25 different ways and you know where one-size-fits-all is just not it, and so there are students that need guided notes. There are students that can go right on to the practice problems. There are students that don't need practice and they need an extension activity and you have to be prepared for all of that.”

The third, and final, emergent theme from the data was the lack of district or administrative support for technology integration and the associated pedagogical training needed. Common to this theme were district roll outs of one to one student to technology ratios with no implementation plan, and no associated pedagogical training. This can be seen in over 62% of survey respondents reporting minimal or no involvement in their district initiatives to roll out new technology. Furthermore, over 60% of responding teachers felt that these initiatives had minimal or no impact on their classroom instruction. When asked to prioritize what teachers perceived to be the main concerns of their districts the expectation that students reach and meet high standards was selected over the use of technology to advance student learning.

Teacher one highlighted this issue in their district, “So, there's not much as far as technology training goes for our staff. So, a lot of the technology that we've integrated into our classrooms, or my colleagues and I have been using, are from things that we have gone out and done professional development conferences on, or where we've gone and learned a different technique and you know. So we've brought that back and shared that with the district, and you know, for us to get the money to do that. It's not necessarily in the plan. We, about three years ago, went through and went one to one with Chromebooks and so our kids are one-to-one. We have sets of Chromebooks in our rooms and we were trained on Google, but the very basics of Google, and they've never taken any further than that.” These was echoed in the roll out from teacher three’s district, “I feel like it's now almost like ‘okay, we're doing these one to one. So, how are you going to use this in your classroom too?’”. They continued, “like I've never really received like legit training. I've just been learning and teaching myself as I go… which has been kind of hard.”

Though districts are rolling out these one to one student to computer initiatives many teachers, especially teacher four, felt that teachers weren’t actually using them, “Our district just kind of got Chromebooks. They're starting a one to one, a thing where all the students would get their own Chromebooks eventually. And we just had access to computer carts in the past couple of years. I'm still integrating it. There's very few classes in my district that are completely what's called flipped, where they include technology all the time. And the students, don't really take well to those designed courses, just from conversations and surveys that I've given them. But I do include it, I would say in more than half of my lessons.”

This sentiment truly sums up the three major themes found in both the original survey and the follow up interviews. This teacher had a positive view of technology, a desire to use student feedback to implement a SCL environment, and a lack of lack of district or administrative support to truly integrate technology into the daily classroom environment.

SCL barriers of implementation

After the data was collected, compared against both the SAMR model and TPACK paradigm, coded and sorted, it was then compared to the five main barriers established towards implementing a balanced student centered learning environment. Those five main areas that can act as a barrier are: psychological, pedagogical, technological, cultural, and pragmatic. Not all barriers were observed in the survey and follow up interviews.

The psychological component of a SCL is centered on how students think, and learn, as individuals. All teachers were found to have profound concern for this. Teacher six specifically highlighted this, unprompted, at the start of their interview, “There’s a lot of information that students want to share and already know. It's very, very, important that it's not just the educator fulfilling knowledge and the students are preceptors of knowledge, that students really have the chance to benefit and share what they know. I want them to accomplish what's achievable with each student, because each student is going to come up with a different level of mastery." Teacher two echoed that sentiment, "the way I deliver a lesson, and the methods, depend on those different learning styles and abilities."

The second component of a balanced SCL is the pedagogical domain. This domain specifically aims to examine the methodology, activities, and inherent structures of a student-centered learning environment. As reported, all teachers felt that they had the pedagogical training to offer a SCL environment, but not the pedagogical training to incorporate technology into their daily classroom. Teacher four had explicit training in SCL environments and used it to analyze data to determine instruction to differing levels of students. They reported, "I really, really look at the previous year test scores. I teach a lot of ninth graders, so I actually get their scores from their eighth grade teachers and how they performed on their science standardized tests in middle school to kind of see where they stand, and I use that. And then from there I can target the groups that are strong and weak, and when I do group work, I can kind of seat them together."

The third component to a balanced SCL environment is the technological domain. The technological domain seeks to optimize new, and available, technologies to achieve a desired outcome in the classroom. This domain was found to be a barrier. While technology is present in some form in each classroom either survey or interviewed, the optimization of the technologies is not present. This can be seen in the relatively low level of TPACK activity types examined and the reliance on technology to operate on the first half of the SAMR model. The uses of technology were found to rely heavily on substitution and augmentation uses, rather than modification and redefinition.

Only two teachers were implementing activities characteristic of the modification level (M) or redefinition level ® of the SAMR model. The second piece, which proved to be a barrier, was using the technology to achieve a desired outcome. In most cases the desired outcome was simply to have technology in the classroom. A truly balanced SCL has an intended goal for the technology being used, or implemented. All of the teachers interviewed reported that their districts gave them some form of a tablet to use, with no specifics on use, applications, or levels of implementation. Teacher one specifically mentioned applying for grants to receive training on how to better use technology in their classroom, as the majority of their technology uses fell in the substitution category of SAMR.

The fourth aspect of a balanced SCL is culture. This is critical as educators must look at the society, or region, their educational system operates in. This was not found to be a barrier in any of the teachers interviewed. In fact, all teachers mentioned that their students were a part of the different generation than they were, and had to teach a way they would be receptive to. Teacher two specifically offered that their students use technology in their daily lives and their efforts to incorporate it into their lesson was a way to connect with them, rather than fulfil a district mandate. Beyond the generational aspects of culture, all of the teachers were aware of their demographics, learning abilities or styles, and school system; with the knowledge of how to best operate in it. Teacher five specifically said, "in public school, half the time you're working on many different things. You're working with helping kids on their day to day problems." When talking about classroom style teacher one specifically said that is dependent on "student clientele", highlighting the different cultures present in their classroom.

Lastly, one must consider the pragmatic foundations of a student centered learning environment, which are often categorized as budget constraints, lack of personnel and equipment, time to do a certain activity, or classroom size. Teacher five highlighted many of these issues by sharing that their district doubled the amount of time students spend taking science, without doubling classroom resources or personnel to support technology integration. Teacher four mentioned budgeting time, down to six minute classroom increments, to meet the needs of her classroom, given the size and resources available. While purchasing the actual technology did not prove to be a budget constraint for any of the interviewed teachers, all referenced only having one technology specialist per school, which can be related back to a budgetary issue.

Of the five main domains of a properly balanced student centered learning environment barriers were found in the pragmatic, pedagogical, and technological domains. Barriers were not identified in the cultural or psychological domains, with these areas serving as high points of the interviewed teachers instructional methods and understanding. Barriers did not follow any trend of subject taught, years teaching, or type of district. The commonalities found were shared across the spectrum of teachers interviewed. Conversely, the strengths observed in psychological and cultural domains were not present at a higher rate in the same categories of subject taught, years teaching, or type of district. They were shared equally over these demographic distinctions.

Conclusions

This chapter contains the results of the analysis, connects the analysis back to the four stated research questions, and establishes consistency of the analysis with grounded theory methodology. Fifty one teachers were surveyed on their demographics, involvement in SCL initiatives, and technology integration. All teachers had at least two years actively working in the education field. From this survey sample six teachers were invited to be interviewed on their classroom set up and teacher training as it relates to both SCL and technology.

It was determined that teachers receive little to no training to deliver secondary science content using technology. Technology and SCL were found to be present in all secondary science classrooms, to varying degrees. True TPACK was only observed in two of the interviewed teachers, with the TPK being self-taught. The SCL activity types most frequently found in the secondary science classroom were comprehensive student portfolios, engaged classroom discussion and debate, extended comprehensive projects, and classroom collaboration tools and assignments. The instructional tools most commonly used were Google classroom and electronic books or course materials.

From these two data sets the recurring ideas and topics were categorized to find three major themes: positive views and perceptions of instructional technology even with no pedagogical training, favorable views of SCL with frequent daily classroom integration, and the recurring theme of lack of district or administrative support for technology integration in the classroom. Chapter 5 includes the summary and critical analysis of these three major themes.

Chapter 5: DISCUSSION

The purpose of this qualitative grounded theory study was to determine which conditions exist to create declines, or stagnation, of technology integration in the secondary science classroom. This chapter includes a discussion of major findings as related to the literature on technology integration in the secondary science classroom, conditions that limit Student Centered Learning and instructional technology integration, and possible connections between TPACK activity types and SAMR activities. Also included is a discussion on connections to this study and teachers' perception of their classroom set up, given pragmatic constraints. This chapter concludes with information on the limitations of the study, suggestions of areas for future research, and a summary of the implemented study and findings.

This chapter contains discussion and potential research paths to help answer the stated research questions:

RQ 1: What training do educators receive to implement and deliver secondary science content using technology?

RQ 2: How prevalent is the implementation of:

- SCL in secondary science classrooms?
- Technology in the secondary science classroom?

RQ3: What SCL activity types are educators currently utilizing in the secondary science classroom?

RQ4: What instructional technology tools are educators currently utilizing in the secondary science classroom?

The theory for what limits the use of instructional technology in the secondary science classroom is multi-dimensional and encompassed in three main themes: (a) positive views of technology with no pedagogical training, (b) favorable views of SCL with daily classroom integration, and (c) the theme of lack of district or administrative support. The positive views found to be held by the majority of secondary science teachers cannot overcome a lack of pedagogical knowledge, accompanied by school district support in either financial or pedagogical opportunities.

Interpretation of the Findings

While their age, school district size or type, years teaching, and subject taught varied for each of the 51 teachers involved in this study, each of the three common themes emerged to give insight in the lived experience and challenges faced by the six teachers interviewed. These themes have a complex nature to them, as each district, classroom, and teacher is incredibly nuanced. Each theme is described in detail in the following sections.

Positive views of technology with no pedagogical training

In 2011 it was determined that a 4:1 ratio of students to technology was found in public school classrooms, meaning there was one computer available for every four students in a school, and it was thought to be related to instructional technology methodologies being taught as part of teachers' pre service curriculum and education (Meoller & Reitzes, 2011). That aforementioned ratio is a mean statistic, meaning that some districts may experience a 0:1 ratio with no technology available to their students, while more affluent districts may even have a 2:1 ratio with every student having their access to more than one designated type of technology. At first glance this may seem like an impossible, or unlikely, situation, until you consider the fact that the target population of secondary science teachers have both instructional and scientific technological tools at their disposal. The tools being reported could be as commonplace as a Chromebook, or IPad, or as sophisticated as a 3-D printer or compound microscope with digital imaging capabilities. This study found a surprising 1:1 ratio in the six teachers interviewed. This was not sought out in the sample, and cannot be generalized to say that all students in the greater Pittsburgh region have access to their own piece of instructional technology equipment. However, this finding can be related back to the main research questions of this study to show that technology is very prevalent in some form the secondary science classroom.

The views that the teachers had in the study on technology can be summed up as positive. The question the research then leads to is: why isn't it being used more? This study found that the issue is not the frequency it is being used, but how, or to what extent, it is being used. It is not unreasonable to say that technology is used in their classroom on a daily basis, for the majority of the teachers in the study. Upon further investigation it was found that the daily uses are more basic than one would hope, given the seemingly endless possibilities technology can offer. Course management software was found to be the instructional tool used most frequently on a daily basis. This is not an overtly bad thing in itself, or something one would seek to change. It speaks to the fact that none of the teachers surveyed had pedagogical training on how to implement diverse forms of technology in their classroom. It did not appear as part of their bachelors or masters preparation or as a mandated district in-service. This is especially troubling, as all of teachers interviewed were enthusiastic about their science content and technology tools, and wanted to encourage more students to go into STEM fields.

For many years researchers have examined why science is often reported as being hard to learn, or a difficult subject to grasp (McClerry & Tindall, 1999; Fiorella, Vogel, & Schatz, 2012). Technology has proven to show positive gains in these areas, as researchers and educators look for ways to improve performance and retention of material in science classrooms (Wu & Albion, 2016). Given these facts it is not surprising that school districts are looking to increase the resources devoted to science education. This cannot be done without proper pedagogy on part of the teachers. All six interviewed teachers made reference to experience of trial and error, characterized by self-exploration and experimentation. When asked if technology had ever negatively affected their classroom experience two interviewed teachers made reference to a time when they selected the wrong technology. In both cases the technology was too advanced and caused great confusion in the classroom. In these instances the educator had to back track and find a new way to introduce a topic, and subsequently lost valuable class time to make up with the confusion. This could have been easily avoided with a solid understanding of how to match up an appropriate technology with a given population and subject matter. These are only examples of six interviews, but it stands to reason that this is not a phenomena unique to these teachers. To further highlight the potential pitfall of this, both teachers were in different age groups, different education levels, and were teaching in different districts. One could not make the conclusion that this type of misjudgment is a beginning teacher's folly, or that it was a result of lack of district infrastructure.

Each of the six teachers interviewed had very positive views of technology in the classroom. When reviewing and coding the interview transcripts it was clear that no negative connotation was hinted at when these teachers spoke of districts roll outs of new technology. In fact, all teachers were excited about the possibilities and then felt discouraged when realizing their own limitations. Common feelings of isolation in the classroom were detected, as each echoed the sentiment that they were 'on their own' to figure things. These feelings came out in the structured interview setting, but it is likely that the survey pool of teachers feels the same way. From that pool only 50% of teachers reported feeling prepared to use forms to technology to offer virtual learning in the classroom.

While it may seem discouraging that teachers are not being offered technology training as a part of their districts' resources, or continuing education, it is hopeful that the teachers widely shared an enthusiasm for learning and using these technologies in their classroom. No teachers had given up, or felt that the technology was a lost cause. Clearly a pedagogical barrier exists in creating a balanced technology integrated student centered learning environment, but it is not an insurmountable barrier as all teacher exhibited an eagerness to learn and better their skills.

Favorable views of SCL with daily classroom integration

Student Centered Learning was found to have an overwhelmingly positive feeling associated with it, regardless of class, teacher, district, or years teaching. All of the teachers viewed it as a best practice and could be said to have classrooms that exhibit the hallmarks of a SCL environment. Common trends and themes were found in all six interviews, as well as the initial survey population. These themes were found to maximize student interactions with the instructor and other students. These trends were most often: testing predictions, student influence on class direction, group projects and discussion, exploration of divergent views and questions. The most striking overarching characteristic of these findings was the ability for student voices to be heard, at multiple levels and in many different ways in the classroom.

When comparing the results of the questions that ask for confidence in implementing a SCL environment the results were much higher than the self-reported results in reported confidence using technology. This stands to reason as most, if not all, of the teachers referenced a best practice taken from their pre-service education training or curriculum. As teachers overwhelmingly felt prepared and capable to implement SCL strategies in their classroom it is not surprising that it was reported to daily use in all of the teacher's responding to the survey. Not a single teacher reported that their instruction was not characterized by critical thinking and problem solving skills, a hallmark of SCL. In keeping with these findings, only 54.55% of teachers said the most important part of their assessment was a traditional test or quiz. Classroom participation was found to be the most important part of assessment for 42.86% of the responding teachers. Other critical pieces of assessment were listed as extended collaborative projects, daily check-ins, and presentations by students to other students.

Teachers also felt that their districts were supportive of efforts to include SCL in their classroom, and most felt that it was a critical piece of their classroom instruction. One cannot say if these teachers feel empowered by their districts, their own pedagogy, their classroom experience, or a mix of these factors but it is clear that SCL is highly valued and is a daily part of these secondary science classrooms. Relevant literature shows that students are more engaged in SCL versus traditional teacher centered learning environments, specifically when they have the ability to determine how the material is being delivered to them (Kortz, Reitze, & Schmidt, 2016).

When interviewing the six selected teachers for follow up, all of the teachers offered a sentiment consistent with the notion that students were driving the education process, not the teacher. The ideas of ‘meeting students where they are’, and offering methods of instruction appropriate to different student learning styles and learning abilities were consistently found in all teachers. The idea that the students’ individual voices need to be heard came out in many of the interviews. As teachers saw positive gains from their students, felt supported in their efforts, and reported having proper pedagogy it is evident that SCL environments are being successfully implemented in these secondary science classrooms.

Lack of district or administrative support for technology integration

A striking theme, that was evident early on in the data analysis, was the theme of school districts and administrators supporting the idea of technology integration without offering the resources to make it happen in a systemic way. Each of the teachers interviewed shared that their district only had one technology person to support the entire school. Each of the teachers also offered that their districts felt that the 1:1 ratio was a high priority for their schools. Many of the teachers hinted at the districts doing this for notoriety, and not true student achievement. It is impossible to say why these conditions exist. All of the sources were considered to be reliable, but none of these teachers were involved in the decision making process or roll out of the technology, so they may not be able to accurately reflection their schools true motivation for supporting technology use.

In general, all of the teachers felt that they did not have the support they needed to truly integrate technology in their classrooms. No benchmarks were offered, no goal setting was set forth, and no exemplars of quality methods of technology integration were given to these teachers. This is unsurprising, as only 39.21% of teachers felt that district initiatives to enhance these things moderately or substantially impacted their teaching. Whether or not these districts are actually offering useful initiatives to enhance their teacher's abilities, the teachers are overwhelmingly saying that the efforts aren't meeting their needs. A similar ratio of teachers, 37.25%, reported that they had involvement in these initiatives. When looking at perceived efficacy of these districts offerings, or mandates, again only 37.25% of teachers felt that they actually impacted their students in the classroom.

Essentially, what the teachers are largely saying is that they have no say in what is offered, the offerings are not what they need, and in the end they do not trickle down and impact the students in the classroom. The apparent disconnect between what teachers need and what is offered could very likely related to how involved the teachers are in the process. It is ironic that districts are pushing these initiatives to enhance SCL. A noted hallmark of SCL is letting your constituents drive their own educational process; something these districts are not doing for their own teachers. Summarily, the ability of school districts to support their teachers' efforts to integrate technology was determined to be a condition that limited the use of instructional technology in the SCL classroom.

Implications for Theory and Research

Chapter II included descriptions of two main theories, or conceptual models, relating to technology integration: SAMR and TPACK. The overarching topic of student centered learning encompasses these models and can utilize them both to aid implementation of a balanced classroom model using instructional technology.

Substitution Augmentation Modification Redefinition (SAMR) Model

The SAMR (substitution, augmentation, modification, and redefinition) model offers a system for categorizing the types of technology teachers are using in the classroom based on how they used and what the goal of their use is. The SAMR model posits that when teachers use technology in a way that modifies or redefines a task, in a way that would not be possible with the technology at hand, the true potential of the technology has been found. When looking at the results of this study it was evident that the majority of the tasks being offered by the sample population would fall under the substitution and augmentation categories, suggesting that the technologies being used by the teachers have further potential to enhance student learning.

In this study only two of the teachers interviewed offered tasks that were characterized under the modification and redefinition categories. This is unsurprising, as none of the teachers reported being properly trained, or assisted, in their efforts to implement technology in the classroom. When looking at substitution and augmentation tasks the given tasks, or assignments, are not changed. In those situations technology is replacing physical resources and materials, or keeping the task at hand the same with an enhancement due to its use. These should not be discounted, or discouraged for use in the classroom. Typing an essay on a computer is not intrinsically more valuable than writing an essay by hand, but it does provide students with an introduction to technology and aids in the habit of using technology in the academic setting. One of the teachers interviewed mentioned that students use technology, generally social media, to such large extents in their home or social lives that it would seem out of the ordinary to not use it in the classroom. When educators limit available technology use to online grading systems, electronic mail, or word processing programs, as reported in this study, they are not unlocking the full potential of the technology that is available.

When a technological tool is used to modify or redefine a task it is being used in way to offer an assignment, or learning experience that would not be possible without it. Each of these were only observed once in two teachers being interviewed for this study. In each situation teachers taught themselves the technology, and through trial and error figured out the best time and place to use it in their classroom. They both reported largely position responses to these assignments. This begs the question of what would be possible if teachers were actually trained to do this. Would their engagement with district initiatives increase if they were deemed useful? Would their students' achievement increase, and ultimately lead to higher numbers of student pursuing careers in the STEM fields? It cannot be said for certain, but given the teachers' motivation towards using the technology, and their relative ease of access, it seems logical that these things would happen.

One SAMR category is not intrinsically more important, or useful, than another but it is crucial to keep in mind that the latter half of the model provides tasks most closely associated with

SCL environments and true technology integration. In this study each teacher had a classroom environment that allowed for a 1:1 ratio of students to technology. If these teachers were not able to offer tasks associated with modification and augmentation it would not seem reasonable to expect teachers with less desirable ratios, reflective of national statistics, to do this.

Technology, Pedagogy, and Content Knowledge (TPACK) Paradigm

As the SAMR model is only offering a way to categorize specifics tasks in relation to how technology is used, an additional framework is needed to give insight into the complicated picture of technology integration in the secondary science classroom. The TPACK paradigm was used to determine which knowledge types the teachers in this study possessed, and what knowledge bases the teachers might be lacking. This analysis ultimately leads to understanding the conditions that exist to limit true technology integration in the classroom.

True TPACK was found to be missing in four out of the six teachers. Only two of the teachers were found to have substantial technological pedagogical knowledge. Without that portion of the Venn diagram true TPACK cannot exist in the classroom. These findings were self-reported by the teachers, and evident in their use of technology in the classroom. These findings are consistent with research, as Hoer and Grandgennet (2012) found that this is the knowledge base that teacher struggle to stay on top of the most. If teachers are not equipped with the knowledge bases intrinsic TPACK it would be nearly impossible to expect them to be offering tasks associated with the upper levels of the SAMR model.

If one doesn't have pedagogical knowledge relating to how to use technology, there would be no way for them to offer a redefinition task in their classroom. A teacher cannot offer a transformative experience using technology if they have no training or pedagogical background to do so. This is highlighted in the trial and error experiences highlighted by many of the teachers. It should be noted that there was no relationship found between an increased SCL environment (frequent used of SCL tools and activities) and comprehensive TPACK understanding. The teachers that possessed TPK were not found to be more supportive of SCL, or using it at a higher rate in their classrooms.

Harris and Hoffer took the TPACK paradigm a step further and offered the concept of activity types (2009). These activity types are not necessarily associated with technology, as in the SAMR model. The activity types Harris and Hoffer studied were the activities that took place in the daily classroom. An activity type in this framework could be a book report, a presentation, or even the fly breeding lab mentioned by teacher 5. This model gives teachers the notion that increased activity types in a classroom gives a more authentic SCL experience, especially when using appropriate technology. As there are three knowledge bases to TPACK (technology, pedagogy, and content), the differing activity types relate back to specific categories, or their intersection. The two teachers found to be offering the most activity types were found to be exhibiting true TPACK as well. These findings are consistent with the model, as increased knowledge bases would naturally lead to increased activities in the classroom.

The link between TPACK domains and activity types proved to be consistent. Another consistent trend was noticed, that has not been explored in literature before. This trend is the relation between TPACK activity types and SAMR tasks. The teachers found to have true TPACK were also found to be the only teachers exhibiting modification and redefinition tasks. As this is a relatively small sample size it cannot be definitely said that balanced TPACK will always lead to innovative tasks in the SCL classroom. The link between SAMR and TPACK is logical. If a teacher does not have TPK they likely cannot offer a task that was not possible without the technology at hand. A preliminary hypothesis of this study is that SAMR is the natural way to measure the outcomes of TPACK. This study suggests that the modification and redefinition of tasks categorized by SAMR are only possible with TPK. Increased TPK, and ultimately TPACK, is the best way to increase the numbers of activity types highlighted by the upper tier of the SAMR model.

Student Centered Learning Barriers

Five barriers, or domains, may possibly exist in any classroom to inhibit a properly balanced student centered learning environment: psychological, pedagogical, pragmatic, technological, and cultural. While all of the six teachers interviewed, and the majority of the teachers surveyed, were supportive of SCL there were barriers observed in the pedagogical, pragmatic, and technological domains that would allow for a truly balanced SCL environment in the secondary science classroom.

When rolling out initiatives to enhance SCL only three teachers of the entire survey population reported that they had substantial involvement in the process, and consequently only three teachers, not the exact same three teachers, felt that these initiatives transformed the way they teach. Only four teachers of the 51 teacher sample similarly reported that they feel very well prepared to offer personalization in their classroom, a hallmark of SCL. These basic statistics point to overarching barriers in the pedagogical, pragmatic, and technological domains of a balance SCL environment. These findings can be generalized over the 51 person survey pool.

Looking at the six teachers interviews in depth, these same barriers emerge with greater complexity. Of the six teachers interviewed only two teachers, case 2, were able to overcome these barriers and implement technology in a balanced and pedagogically sound approach. They exhibited more confidence in their ability to alter tasks and use different technologies, which may suggest a psychological barrier on behalf of the teachers in case 1.

These results connect back to the theoretical framework of SCL and show that these missing pieces inhibit the implementation of a truly balanced SCL environment. These domains do not exist in a vacuum and overlap with great effect on each other.

Implications for Practice

The results of this study prove that teachers want to use technology, and they especially want to use it to offer a balanced student centered learning environment. This study also proves that teachers are not given the tools they need to make this happen, either as training in their degree programs, continuing education, or district offerings. Very simply, the study shows that implementation of technology matters a great deal. Each of the teachers of the interview portion of the study had a 1:1 study to technology ratio. None of those teachers were a part of an implementation team, or had access to such a team. Technology was present in each of the classrooms, but not in a higher order way.

All of the teachers interviewed mentioned some type of district in service in this calendar year, and none were related to technology integration in the classroom. One teacher recently attended a Pennsylvania State Education Association (PSEA) conference and voluntarily chose to attend a session demonstrating new technological tools to use in the classroom. They reported that the session was interesting, but they ultimately left feeling discouraged as they were unsure of the technology’s place in their classroom. This speaks to the lack of PTK in the majority of teachers. School districts cannot keep offering trainings on basic technology if they expect technology to enhance student learning in novel and meaningful ways.

Most of the teachers interviewed made reference to state standards, or district measurements of achievement. This study shows that it is possible to look at classroom achievement in other ways. To measure the effectiveness of a teacher this study places value on using the SAMR model to measure classroom instruction. The teachers interviewed were all using technology to certain extents, but not at the higher levels that research shows can effect classroom change. Professional development opportunities need to be offered on models such as SAMR and TPACK so that teachers can adequately measure their own activities.

In 2001, the Council of Chief State School Officers compiled results relating to policy changes and classroom instruction. They found evidence that policies have changed practice in the ways predicted; but implementation is critical of these new policies. This is critical to keep in mind as there is a link to this study. Each school has enacted policies to put technology in the classroom, but there were no systemic implementation plans for the teachers interviewed. A comprehensive plan should also include training in TPK to enhance results. The findings of this study show that the educational community needs to refocus evaluation and training efforts to better meet the needs of the teachers in the classroom.

Most of the teachers received basic training on how to use Google classroom. As a result, the reported uses of technology were on the lower end of the SAMR scale. Districts, and researchers, cannot be surprised to find that Google classroom is mostly used as a digital drop box or gradebook, even with its seemingly unlimited uses. The trainings that need to be offered have to be pedagogical training on selecting appropriate technology in the STEM classroom. If these trainings were offered teachers would likely exhibit tasks on the higher end of the SAMR scale, and a higher number of TPACK activity types.

If this proper, and in depth, training was offered perhaps the tasks Google classroom would be used for would be cross district student experiments that use technology to collect data, present findings, and collaborate to achieve greater scientific knowledge in the SCL environment. In addition to the training being offered, true development time is required for teachers to implement these tools in a strategic way. One teacher in the study mentioned class periods being shifted from 40 to 80 minutes with no additional planning time to extend the lessons, let alone augment them with meaningful technology. It has already been demonstrated that when teacher keep logs of their instruction time that they engage in a self-reflective practice that allows them to truly examine the content they are delivering (Rowan & Ball, 2005). When looking at these previous example there was simply no time, or resources, for that to happen. A suggested reason for the lower forms of technology integration is likely an issue of time, which speaks to the pragmatic barrier of implanting a SCL. If a teacher has no time to enter grades and manage their classroom effectively, it stands to reason that they will need seek out additional training on models like SAMR and TPACK, which would ultimately lead to increased activity types in the classroom.

As mentioned, no link was found between increased observance of a SCL in teacher that used higher SAMR levels, or possessed every knowledge based in TPACK. TPACK certainly offers a balanced SCL, but it was not found to be the only way to offer SCL environments. Given this apparent connect between SAMR and TPACK, increased knowledge of these domains can only bolster already high levels of SCL in the classroom.

Limitations of this Study

While the researcher posits that qualitative research was the right choice for this study, the qualitative research tools employed, like interviews or original materials collections, are not designed to capture concrete and large groups of generalizable facts. Furthur insight into this topic can be given by adding an quantitative element. For example, a survey designed for quantitative fact finding, and associated statistical analysis, could offer more evidence to strengthen the data discovered in the six main interviews.

The use of additional targeted demographics could add to the findings in this study, as there was not a high response rate from the private, non-parochial, school sector. A quantitative study could be developed to look a wider range of schools, with the eventual aim of a robust state wide study. As these results only speak to the greater Pittsburgh and Allegheny County area it is not possible to say that the same findings would be found in the middle of state or in the greater Philadelphia school system. This study's participants came from largely suburban school districts. A targeted study that seeks to compare the findings in urban versus suburban populations would aid in making these findings generalizable to the entire region.

Recommendations for Future Research

The findings of this study call for further research into several areas under the umbrella of technology integration and student centered learning. As the field of instructional technology is constantly evolving there are several directions future studies could take, using the aforementioned research as a starting point.

A suggested area of study would be the students in the STEM classrooms themselves. Many of the studies on SCL and TPACK focus on the educators. A logical next step would be to compare the achievement of students in classrooms of teachers with robust TPACK, compared to their peers in classrooms of teachers with only PCK or TCK. If this was done the relationship between the higher end of the SAMR model and the number of TPACK activity types could then be definitively linked.

Additionally, a study looking at the effects of training in TPK would be useful in advanced TPK and SCL knowledge. It would greatly help the available body of literature if a study was executed that offered training in TPK to a willing teacher population and then examined their activity types and SAMR activities after the training. This researcher would hypothesize that these two metrics would increase, given the findings of the study. However, that cannot be conclusively said given the small sample size of this population.

Conclusion

Technology can be a valuable tool in the classroom, and students use it daily in their personal lives. It is often seen as magic tool that can fix classroom problems and improve results. However, its full potential can be only be unlocked when teachers have the tools they need to implement it properly. This study shows that teachers do not have these tools, but remain optimistic about the place of technology in their classroom and have a real desire to use it.

Student centered learning has proven to be an effective mode to deliver classroom content. There are five recognized barriers in implementing a truly balanced SCL classroom environment: psychological, pedagogical, pragmatic, technological, and cultural. Teachers were found to be offering SCL activities in their classroom, but very real barriers existed in the pedagogical, pragmatic, and technological domains.

It is easy to look at teachers when examining any faults in our educational system, real or perceived. They are often the first place the public lays blame with if the United States falls in educational rankings or there is a high profile example of education failing a student. This study shows that further investigation is needed before quickly placing blame on our nation's educators. Barriers exist in allowing teacher to reach their full potential in the classroom.

The results of this study suggest three themes that highlight these concerns: 1) positive views of technology with no pedagogical training, 2) favorable views of SCL with daily classroom integration, 3) and lack of district or administrative support. Further study should be done to examine how effectively training teachers in TPACK can affect student success in the classroom.

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Appendix A

Student Centered Learning Classroom Survey

SCL survey is developed by, and property of Education Development Center Inc.

1. What is the name of your school?

[] (School #1)

[] (School #2)

2. What subject(s) do you currently teach? (Check all that apply)

[] ELA

[] Mathematics

[] History/Social Studies

[] Science

[] Art

[] Foreign Language

[] Physical Education

[] ELL or ESL

[] Special Education

[] Other (please specify)

3. Are you male or female?

[] Male [] Female

4. Please indicate your race/ethnicity [] American Indian or Alaskan Native [] Asian or Asian American

[] Black or African American

[] Hispanic or Latino/Latina

[] Native Hawaiian or Other Pacific Islander [] White or European American

[] Two or more races

5. How many years have you taught including the current school year?

[] 0–1

[] 2–5

[] 6–10

[] 11–20

[] more than 20

5. Indicate the grade level or levels that reflect the majority of your teaching during this school year.

Involvement in District SCL Activities and Impact on Instruction and Assessment (section 2 of 5)

7. To date, how much involvement have you had in the {district} initiatives to enhance student-centered learning (e.g. Anytime/Anywhere learning, Proficiency-based learning, and Personalized learning)?

8. How much impact do you believe the {district} initiatives to enhance student-centered learning (e.g. Anytime/ Anywhere learning, Proficiency-based learning, and Personalized learning) have had on your instruction in the past year?

9. How wide an impact do you believe the {district} initiatives to enhance student-centered learning (e.g. Anytime/ Anywhere learning, Proficiency-based learning, and Personalized learning) have had on student engagement and/or college and career readiness this past year?

10. How wide an impact do you believe the {district} initiatives to enhance student-centered learning (e.g. Anytime/ Anywhere learning, Proficiency-based learning, and Personalized learning) have had on what, when, where, and from whom students learned in the past year?

11. Given the work of the {district} initiatives to enhance student-centered learning (e.g. Anytime/Anywhere learning, Proficiency-based learning, and Personalized learning) over the past year, how well prepared do you now feel to support student learning that:

REQUIRES COLLABORATION

REQUIRES PERSONALIZATION

REQUIRES CRITICAL THINKING OR PROBLEM SOLVING

REQUIRES STUDENT SELF-REGULATION AND ACADEMIC TENACITY

REQUIRES ANYWHERE/ANYTIME LEARNING

12. In your classroom over the past year, how often did you provide instruction that:

REQUIRES COLLABORATION

REQUIRES PERSONALIZATION

REQUIRES CRITICAL THINKING OR PROBLEM SOLVING

REQUIRES STUDENT SELF-REGULATION AND ACADEMIC TENACITY

REQUIRES ANYWHERE/ANYTIME LEARNING

13. Of the assessment methods listed below, please indicate the three that are most important for assessing student proficiency in your classes. Indicate the methods you would rank as the first, second, and third most important.

Traditional quizzes or tests

Portfolio submissions and accompanying rationale

Classroom participation

End-of-course or end-of-term exams

Extended (more than a week long) individual projects

Extended (more than a week long) collaborative projects

Daily homework and daily check-ins

Student writing (essays, reports, etc.)

Journals, Lab books or Notebooks

Student presentation to class

Student presentation at a public event or to a panel of students, teachers, administrators and/or community members

School Support and Collaborative Culture (section 3 of 5)

14. Based on your experiences during this school year, to what extent does your school support the following (Check one box in each row).

My school supports:

a. alternative pathways to graduation

b. efforts to personalize instruction to meet student needs

c. student participation in extended learning opportunities (ELOs) for credit

e. the expectation that all students can reach high standards

My school supports:

f. students in regulating their own learning and setting their own pace

g. the use of multiple measures of student performance to assess mastery

and to determine whether/when students advance to more challenging content

h. students in setting and meeting long term goals

i. student voice and leadership

15. Based on your experiences during this school year, to what extent to you agree or disagree with the following statements? (Check one box in each row).

Most teachers in my school:

a. have similar ideas about how students learn

b. are familiar with each other's teaching goals

c. are familiar with each other's classroom practices

d. have a shared vision of effective instruction

e. have similar ideas about how student work should be assessed

f. ask for assistance from one another

g. share teaching strategies with each other

i. have opportunities to observe one another teach

j. want to be observed by other teachers

k. work together to plan curriculum and/or instruction

16. Please rate the following instructional activities for how important they've been to your instruction in this school year. (Check one box in each row.)

b. provide instruction through extended formal presentation/lecture

d. organize and facilitate a student-led activity

e. students stay on task

g. ask open-ended questions to promote engagement with big ideas

h. give written feedback on student work

i. give oral feedback on student work

k. modify or adjust instruction based on informal classroom assessments

l. model for students how to approach a problem or task

m. use technology to personalize instruction

n. differentiate activities or instruction to meet individual students' needs

o. make connections between content and/or activities and students

17. Of the instructional activities described above, which three take up most of your teaching time (inside class) over the course of a typical week?

Select the three activities that take up first, second, and third most time.

b. provide instruction through extended formal presentation/lecture

d. organize and facilitate a student-led activity

e. provide students with in-depth guidance on the content or organization of their work

g. ask open-ended questions to promote engagement with big ideas

h. give written feedback on student work

i. give oral feedback on student work

j. have students explore alternative methods for solving problems/conducting investigations

k. modify or adjust instruction based on informal classroom assessments

l. model for students how to approach a problem or task

m. use technology to personalize instruction

n. differentiate activities or instruction to meet individual student's needs

18. When participating in your class, how often have students engaged in the following types of activities during this school year: (Check one box in each row)

Never Rarely Sometimes Often Every day

a. participate student-led discussions or activities

b. participate in discussions led by the teacher

c. listen to teacher presentation/lecture

d. make formal presentations to the class

e. work together in pairs or small groups on an assigned task

f. work individually on an assigned task

g. explain their reasoning or defend a position orally or in writing

h. answer textbook/worksheet questions

i. design or implement their own investigations or research projects

j. write reflections on progress

k. work on materials for a portfolio

l. engage in performance assessments involving teachers and peers

m. take notes

Appendix B

Follow up survey interview questions

1. What is the goal of your classroom (to provide students with knowledge, have students think about material during class, or have students construct their own knowledge)?
2. What percent of your class do you typically find yourself speaking/offering direct instruction (95%, 90%, or 50%?)
3. What percent of your class time do students do something other than take notes? What are those activities?
4. Do students in your classroom work alone, talk to each other, or combine to debate/formulate ideas/predict hypothesis/test ideas?
5. Do you ask students questions to seek a specific answer, call on students, or solicit multiple answers to critique and analyze as a group?
6. Do students in your class seldom ask questions, ask questions within the context of your material, or ask questions that are answered by other students in the classroom?
7. Are students are engaged in a learning environment that addresses different student needs?
    a. What are some of those needs?
    b. How are they assessed?
    c. How are you trained/directed to address them?
8. Do you give instruction to students prior to teaching the lesson?
    a. If yes, are they informed of learner goals and how?
    b. If no, why?
9. Do students engage in the lessons through various learning objectives and use a variety of resources?
    a. What resources are most typically used?

i. How are they selected?

ii. What are some successes you have had with outside resources?

10. Do students participate in a variety of activities that are appropriate for the time allocated to teach the lesson?

    a. What are those activities (type)?

        i. How are they selected?

        ii. How are they modified?

11. How are students assessed?

    a. Are you using a mix of formative and summative assessment techniques and instruments?

        i. If so, which types?

        ii. If not, why?

12. Do students engage in various modalities of learning (e.g., discussion, collaboration, inquiry, problem-solving, predicting, etc.).

    a. Which is most common?

    b. Which is most efficacious in advancing student learning in your opinion?

13. How do you insure that students are engaged in higher levels of thinking (inside or outside of the lesson)?

14. Do you feel that student interactions give evidence of learning and assessment?

    a. Can you give an example of this?

    b. Has it ever had a negative impact on the lesson?

15. Do students track their own mastery of content?

    a. Is there assistance from their teacher? How is that done?

16. Are students are provided examples of quality work through exemplars?

    a. What is the reaction to this?

17. Is technology is easily accessible and integrated in some or all of the lesson?

    a. When is it used?

    b. How do you determine what is used?

    c. Has this ever negatively impacted your teaching?

18. Do students use technology to extend their learning beyond the classroom?

    a. How is that measured or observed?

19. Do students use technology to solve problems individually and/or in collaborative teams?

    a. How is that measured or observed?

Appendix C

Consent to Participate

DUQUESNE UNIVERSITY

PITTSBURGH, PENNSYLVANIA

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TITLE:
An investigation of technology implementation through the lens of Student Centered Learning and the Technological Pedagogical Content Knowledge paradigm

INVESTIGATOR:
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SOURCE OF SUPPORT:
This study is being performed as partial fulfillment of the requirements for the doctoral degree in Instructional Technology and leadership from the School of Education at Duquesne University.

STUDY OVERVIEW:
In this study an initial survey will be offered with questions pertaining to classroom teaching style, instructional technology, education activity types, and classroom support.

After completion of this interview six participants will be invited to a one on one interview, in person or through Zoom conferencing.

After completion of the interview a second meeting will be scheduled to insure accuracy of recorded content collected and transcribed.

PURPOSE:
You are being asked to participate in a research project that is investigating educators receive to implement or deliver secondary science content using technology, and the associated methods used in the classroom.

In order to qualify for participation, you must be licensed to teacher in Pennsylvania and be employed as a teacher in Allegheny County.

PARTICIPANT PROCEDURES:
If you provide your consent to participate, you will be asked to complete a survey based on the Nellie Mae Foundation's Student-Centered Learning (SCL) Questionnaire for Teachers. The time to complete this survey should not exceed 45 minutes. This will be sent via e-mail with a link for completion on the Survey Monkey survey tool.

In addition, you may be asked to allow me to interview you. The interviews will be audio recorded and transcribed. The interview will not exceed two hours of your time.

RISKS AND BENEFITS:
There are minimal risks associated with participating in this study, but no greater than those encountered in everyday life.

The benefits of participating in this study include the advancement of research and understanding of teachers' classroom experience and possibility of a Barnes & Noble gift card.

COMPENSATION:
There will be no compensation for this study. Participants will be eligible for 5 $25 Barnes and Noble gift cards, to be randomly selected.
There is no cost for you to participate in this research project.

CONFIDENTIALITY:
Your participation in this study, and any identifiable personal information you provide, will be kept confidential to every extent possible, and will be destroyed after 3 years' time once the data collection is completed. Your name will never appear on any survey or research instruments. All written and electronic forms and study materials will be kept secure on a password protected server at Duquesne University. If Zoom conferences are requested the recordings will be deleted after completion of this study.

In addition, any publications or presentations about this research will only use data that is combined together with all subjects; therefore, no one will be able to determine how you responded.

RIGHT TO WITHDRAW:

You are under no obligation to start or continue this study. You can withdraw at any time without penalty or consequence by e-mailing wasilkoa@duq.edu or calling 412-xxx-xxxx

SUMMARY OF RESULTS:
A summary of the results of this study will be provided to at no cost. You may request this summary by contacting the researchers and requesting it. The information provided to you will not be your individual responses, but rather a summary of what was discovered during the research project as a whole.

FUTURE USE OF DATA:
Any information collected that can identify you will not be used for future research studies, nor will it be provided to other researchers.

VOLUNTARY CONSENT:
I have read this informed consent form and understand what is being requested of me. I also understand that my participation is voluntary and that I am free to withdraw at any time, for any reason without any consequences. Based on this, I certify I am willing to participate in this research project.

I understand that if I have any questions about my participation in this study, I may contact Adam Wasilko at 412-xxx-xxxx or wasilkoa@duq.edu. If I have any questions regarding my rights and protections as a subject in this study, I can contact Dr. David Delmonico, Chair of the Duquesne University Institutional Review Board for the Protection of Human Subjects at

412.396.1886 or at irb@duq.edu.

This project has been approved/verified by
Duquesne University's Institutional Review Board.

Appendix D

Teacher 1 Interview

Interviewer: Okay, first question is about your classroom instruction style. What would you say is the goal of your classroom? Would you categorize it as providing students with knowledge having students thinking about their material during class or having students construct their own knowledge?

Teacher 1: I think it's a nice balance of all three. I want my students to feel empowered in my classroom if I can provide with a couple of ideas to start out the day and then we can kind of flow, get a knowledge flow going, some curiosity asking the right questions in a classroom is very important. So how to kind of illicit that curiosity from your students. Okay.

Interviewer: So what percent of your class do you typically find yourself just lecturing or offering direct instruction to your students? Would you say more than or less than 50%?

Teacher 1: It varies by day, but I think the majority of the days it is probably 50 to 60 percent, and I think it's important here to note that my courses are on an 80 minute block schedule for 90 days. So there is quite a lot of content to cover over those

90 days, thinking about how you're losing days for you know days for assessment school-wide testing things of that nature. It's not ideal but it is, but, there are most days that I have to make sure that we get in the content that we need to get in.

Interviewer: And do you feel like there are certain topics that lend themselves to direct instruction or lecture better than others.

Teacher 1: Absolutely. There are there without a doubt. Topics that perhaps are taught over 3 or 4 days where the first day you're kind of laying the groundwork, but the next couple of days it's more Discovery and understanding from the student perspective rather than guiding the instruction.

Interviewer: Okay, so I'm assuming when you're lecturing ideally your students are taking notes. So what percent of your class time do you think students are doing something other than taking notes on your instruction?

Teacher 1: I would say, out of the 80 minute class we're probably taking notes doing some practice examples some Discovery activities probably 50% of the time and then the other aren't, I'm sorry, 50 minutes of the 80 minutes and then the other 30 minutes is for practice, Independent Practice Group projects, group practice Discovery extension activities from whatever the lesson we learned about that week.

Interviewer: Okay. It's like 30 to 40 percent?

Teacher 1: Yeah,

Interviewer: So when students are doing those activities you talked about do they work alone or would you think they talk to each other or with a work in a group? What are they usually doing?

Teacher 1: It really depends on the class, the kind of the student clientele that I have, as well as what exactly the topic is or how I'm assessing it. So if I'm trying to get a quick formative assessment from each student. I would ask that they work independently to demonstrate their knowledge. Perhaps a couple practice problems or a specific kind of constructed response question because I want to see what that child wants, you know is learning however more non graded activities that are formative but non-graded allow me to kind of walk around the room, work with certain groups and listen to the conversations that they're having. Chaos in a classroom is important as long as that chaos is those really great conversations that they're having they're helping each other out not only identifying perhaps mistakes that they're making in their work, but they can kind of help their peers along that are making mistakes and then they learn from that as well. They also become curious if somebody asks, well, how do I do this? And you know, they are able to look back in their notes or look online or ask me for some direction. And so then you know, you have a good kind of assessment of what they need and what they don't need. So I think that it's.Who works with who or how they work together is very much based on the activity. If it's a grade going in the grade book. I'm more than likely like to have it as an individual grade because group work can be skewed and then also if they are working in a group, it's more or less to kind of foster that curiosity in that extensive learning.

Interviewer: Okay. So when you're calling on students in your classroom to ask questions, do you usually have a specific answer in mind you're looking for, do you ask multiple students for different answers or would you ever like have students analyze proposed answers in a group or how does that process work?

Teacher 1: Again, it's based upon what we're doing if I'm looking for a succinct like a specific solution to a problem, you know, obviously that's what I'm looking for.

But if a student answers incorrectly that actually leads to more learning because we can ask some questions of how do we navigate to the correct specific answer if I'm looking for a process. It's definitely collaborative effort between students to collaborate on you know, what's our process for thinking what are things that we have to remember? What are the details that we need to consider when arriving at a solution?

Interviewer: Okay. So in the course of one of your class blocks, did you say 80 minutes?

Teacher 1: Yes,

Interviewer: Do students ask questions a lot? If so, are they say in the context of the material and do you let other students answer those questions or do you usually answer them?

Teacher 1: It's funny to hear in the context of material because I get asked a million questions a day. Sometimes it's winter picture retakes, some of its when's our homework, or how did you get that answer? And I think that I try as best as I can for other students to you know, Johnny says, how did I get that answer and I say well, how did we get that answer? Can someone help Johnny out and that, you know allows other students to reflect on what they've learned or perhaps what they have kind of solved for on their papers and help their peers out. It's a very big thing that's only done if you have fostered a respectful atmosphere in your classroom. That's not that's not easily done in every single classroom. And I think to if time is of the essence quite often, you know, for short on time. I'm the one that is at least addressing the issue not necessarily giving the answer. But okay, where can we find the answer and kind of leading the student to where it is in a problem that we've done an example or in their notes

Interviewer: That make sense. In the environment of your classroom that you're kind of responsible for, would you say your students are engaged in the learning environment that addresses the different needs of students at different levels?

Teacher 1: Absolutely. It is so important if there's one thing I've learned in 10 years. It's that there's you know, you have 25 students learn 25 different ways and you know where one-size-fits-all is just not it and so there are students that need guided notes. There are students that can go right on to the practice problems. There are students that don't need practice and they need an extension activity and you have to be prepared for all of that.

Interviewer: So how do you assess or determine who needs different things and you feel like you're trained to do that?

Or were you trained in your education to do that?

Teacher 1: I think I had…in my education it was. You know, they tell you that it's going to happen and here's some different things and you know, you're supposed to learn what it's like to differentiate but until you have experience in the classroom, or you have somebody that can share experiences with you in the classroom. You don't know exactly what you learn for, you know the kids and there are things that I have learned in my classroom over the last 10 years that nobody ever taught me in my bachelor's program or my master's program and I think that that comes with…..just I'm generally open to going to learn new things read about new things to try my class and my students have changed over 10 years their needs are much different than the students that I had in my first second third year of teaching.

Interviewer: Okay. So when you're starting a new lesson, do you give instruction to your students prior to teaching that lesson, if you do that, like do you inform them of their learner goals, or if you don't do that and you start without kind of the briefing why?

Teacher 1: Some lessons lend themselves to an opening idea. Like here's a problem. How can we solve it type of thing? There are other things that don't we are required to write learning Target obviously student objectives in our lesson plans, but we are to write learning targets on the board and go over those with our students each day. We have to not only point to that, write them in the same place every day, but point to them, you know, we are it could be a learning Target as you know, we're going learn how to factor a polynomial expressions and we have to be able to verbalize that to our students and then revert back to that learning Target at the end of the day and say can you factor do you feel confident with factoring a polynomial expression .Exit ticket? Here's a couple of examples of where you can demonstrate that you know what you're doing.

Interviewer: Okay. So do your students engage in these lessons through various learning objectives? Do you use a lot of different resources? You know, what's the main resources your students use when they're learning?

Teacher 1: Sure, we have there's a lot of things that I do that I've just developed. We have a textbook that has obviously provide supplemental worksheets activities exploration things of that nature, but I've also spent many hours perusing the internet things like Teachers Pay Teachers Pinterest or I've developed my own things based upon what I've seen from what my students know and what works best for my students.

Interviewer: So how do you select those or do you sometimes ever find something and then modify it for your own needs?

Teacher 1: Absolutely so I can select a worksheet. You know, you might search something. Let's just stay with factoring polynomials and they have 50 questions on the worksheet. I can pick and choose which ones are most appropriate for the specific, you know, anchor that I'm assessing or learning target that I'm assessing and just provide that to the students. Also if a student's ability levels, you know are different. I can modify a worksheet for students to do, you know certain problems based on their ability level or where they're at.

Interviewer: Okay, so when you're using all of these different things, how do you assess student achievement in your classroom?

Interviewer: Would you say it was like a mix of formative and summative assessment techniques or what do you use? How do you do that?

Teacher 1: There's a mix of formative and summative assessments. I think it's important to know that we have a secondary grading policy in my district. So their final grade for my course for a quarter grade, for quarter grades. I'm sorry is based off of that. The summative assessments can count no more than 80 percent of their grade and formative assessments should be less than that. They're grade should not be any more than 10% for homework. Be made up of homework. I'm sorry. Let me rephrase that ten percent of their grade for the quarter can be homework, but no more than ten percent can be of their grade can be given for homework.

Interviewer: So you have to watch how many points that you give for each thing. I obviously give more formative assessments because that helps me navigate what I'm going to teach in my class.

Teacher 1: The other thing that's important to remember about the grading policy is no student receives less than a 55% on a summative assessment. So any student who scores below a 55% gets their score rounded up to a 55%. This includes a student who refuses to take an exam. They still get a 55%. So, it's kind of skewed as far as grades go with what you can give them.

Teacher 1: I do offer more formative and summative

Interviewer: And like what are some of those formative?

Teacher 1: So, formative assessments would be a quick quiz a bell ringer a homework assignment some type of graded assignment that is an exploration of what we did in class or a culminating project to bring everything together. Usually they're quick quizzes in the morning and the beginning of the day on the lesson prior and they're based off our homework. Summative assessments would be mid chapter test chapter test a unit test.

Interviewer: Okay, so you're probably aware there are different modalities of learning, right? So there's discussion collaboration inquiry, you know, problem-solving predicting all of these things that are kind of intrinsic to the stem field, which of those you would you say are the most common in your classroom? Which work the best in advancing student learning in the stem field and in your classroom. Or would you say it's an equal mix?

Teacher 1: I think it's an equal mix. I'm still navigating the whole like how much time I have and using it wisely to do that. I will say that this year I teach the same course, I'll judge 90-day Algebra 1 and my first block is more student inquiry and student discussion because that group of students is at the level to do that. My second group is not, so there's a bit more. Some of the first things like, you know instruction followed by discussion, but not so much as eliciting...the…I forget the word you used. I'm sorry.

Interviewer: And so would you say when you're teaching science that you're noticing more discussion and collaboration than when you're teaching math?

Teacher 1: Yes, and I think that's because math is very, unless you could the time of teaching math. If you're being able to apply mathematics to real life examples. There's a lot more discussion there. How do we do this? What tool do we pull from our toolbox to solve this problem? Whereas science there's a lot more, there's different facets of science that can be used and can have you have more of a discussion there. Whereas math. It's like cut and dry. This is kind of how you solve a problem.

Interviewer: Do you feel like you would see more of those different modalities of learning in something like engineering calculus than you would in like algebra class because of like applications?

Teacher 1: Absolutely, I think there should be more applications in algebra class, but in problem, you know kind of that exploratory stuff, but it doesn't always happen because of the time constraints whereas a Calculus class, I think are an engineering class allows for more experiments and more lab-based work.

Interviewer: Okay, so when you're teaching a class like a beginning science class were beginning math class. How do you ensure that students are engaged in higher levels of thinking, you know beyond just what is the right answer to this? So that could be inside the lesson or outside of the lesson or a course objective?

Teacher 1: A nice thing to do is to present them with a problem at the beginning of a unit or a large topic. How do we solve this? And they the students might not even know at the beginning what the ways to answer the problem is, provide them with a real life problem. And so by the end of the lesson they have some or the end of the unit. They have some ideas on what they can do to solve the problem be able to formulate a solution and then communicate how to go about executing.

Interviewer: Okay, so if you have a given lesson and there's some kind of student interactions happening. So that's group work or their problem-solving together or you know, even doing an exam or a workbook together as a class. Do you feel like from based on just those student interactions you have evidence of their learning and mastery of the material?

Teacher 1: Can you repeat that one more time? I'm sorry.

Interviewer: So based on just student interactions. Do you feel like you can tell if they're learning or you that's a part of your assessment?

Teacher 1: It's part of my assessment. It's part of my formative assessment. Unfortunately, you know, there's summative assessment is what is put in the Gradebook. Do I fill that students don't perform necessarily well on paper pencil tests or projects absolutely having a conversation with them, you know, definitely helps and sometimes that's what right so that's why I'm getting exhausted.

Interviewer: Yeah, like through those interactions and yeah student-centered learning things. Can you tell yes their material Mastery?

Teacher 1: Yeah. Sometimes it's much easier for students to explain to me what they're learning rather than putting it on a piece of paper. The student could be a rock star in a classroom during you know practice time or project time, but when it comes to taking a test that completely bomb it, why should the child be graded on something that they're not good, at a paper pencil test right, you know they can if they can commute if they can verbalize to me what they've learned heck. That's great. That's why one of the things I actually read about online and I could start putting on my test is the last question is what did you think was going to be on the assessment that you prepared to answer but then it wasn't on the assessment. What else do you want to tell me about your learning and there are some sometimes I get these brilliant responses. That really makes me think. Okay. This child is doing a lot better than perhaps what the answer key shows.

Interviewer: Okay, do your students track their own mastery of their content?

Teacher 1: They track it during grades, but I would like to work more with standards-based grading because I think that they understand they perhaps would feel better about that type of Mastery, but they do they do look at their letter grades are their percentages.

Interviewer: Okay, but they but like that you enter that or they keep track and you compare notes or they get it from you.

Teacher 1: I enter the gradebook and then they can access their Gradebook.

Interviewer: Okay, are students provided examples of quality work through something you're doing maybe through a project that a former student ID or something from another group?

Teacher 1: Yeah, sometimes when all the time one of the examples in this. Is actually a very poor example because it's a standardized testing example is that we talked about answering constructed response questions on a keystone exam. And so there are some student sample work that show what like a 4/2/3/2/1 is on the scored rubrics and so being able to show students like what are we looking for? As far as an explanation goes or showing your work being able to show those examples, you know is I think what you're what you're referring to.

Interviewer: Yeah, and so thinking about all these things, you know, we've talked about different things you use technology for would you say technology is easily accessible and integrated in some or all of your lessons

Teacher 1: Some.

Interviewer: And when is it used and how do you determine that?

Teacher 1: Graphing calculators are used in my classroom. I want them to be able to do things by hand, but the graphing calculator allows to explore for exploration. So if we're talking about graphing lines and figuring out, you know perhaps where different graphs intersect. It might not always be accessible to do those type of graphs by hand. But it like graphing calculator would allow us to kind of plot some data and make some conjectures.

Interviewer: Right? So if like a student is using that like the lab setting or something like that, do you feel that's ever like technology is ever negatively impacted or hindered your teaching?

Teacher 1: Absolutely not I think it's used to support about teaching

Interviewer: So do you think students use technology to extend their learning beyond the classroom? Like they take anything from the classroom and take it outside? Would your students ever look up an app or anything like that that might help them or would you have to guide that?

Teacher 1: No, they would definitely do it because. They're interested in that and they're interested in technology and what you so it's out there.

Interviewer: How is that just like a basic like a direct observation you make of students told you that do they ask for it?

Teacher 1: Yeah direct observation. Okay are they'll come in and say, you know, I was doing X Y & Z and I discovered that this was on the calculator and look what the calculator can do here. Wouldn't that be helpful in you know this setting or write this situation?

Interviewer: Does your district set any benchmarks or goals for technology integration, or are they supportive if you need a new program or would they not let you do it I wasn't something that was in a district plan. Like is there any organized effort? I guess I'm getting at.

Teacher 1: Yeah, absolutely. So there's not much as far as technology training is goes for our staff. So a lot of the technology that we've integrated into our classrooms or my colleagues and I have been from things that we have gone out and done professional development conferences where we've gone and learned a different technique and you know. So we've brought that back and shared that with the district and you know for us to get the money to do that. It's not necessarily in the plan. So there is an Education Foundation in my district that you can apply for a grant three times a year to do but, not necessarily.

Teacher 1: Not necessarily something that they're willing to give up the money to do. We, about three years ago went through and went one to one with Chromebooks and so our kids are one-to-one. We have sets of Chromebooks in our rooms and we were trained on Google, but the very basics of Google, and they've never taken any further than that.

Interviewer: Okay. If the students using their Chromebook or a calculator or any other piece of technology, do you think in your classroom that happens for individually or in collaborative teams?

Teacher 1: Individually and collaboratively. But okay. Yeah. Yes.

Interviewer: So what I'm really getting at here is kind of technology and its usage in the classroom when it comes to student centered learning. Is there anything final you would kind of like to say about instructional technology either in the classroom like things you would want to learn to do, things you feel like you could do better or things your District to be more supportive of?

Teacher 1: Absolutely. I would like to. To have an opportunity to program the I have the calculators to program but to have the robots to program I think would be a great component to a stem environment and I think that would be something great to research and look into and speak with other, you know, districts that do that but the time and effort is not necessarily there and I would have to take my own personal work time to go and do that or my evenings are my weekends,

Interviewer: Do you feel like you have the pedagogical background to do that if you had the time?

Teacher 1: No, I would have to I would have to take my own time to learn about it.

Appendix E

Teacher 2 Interview

Interviewer: So the first question is what is the goal of your classroom? Would you say it to provide students with knowledge have students think about material during class or have students construct their own knowledge?

Teacher 2: I would probably say somewhere in between, like, I would say obviously providing them with knowledge but also like constructing their knowledge as well where they could like, you know, come up with things on their own.

Interviewer: Question 2 what percent of your class you find yourself typically speaking lecturing offer and just like direct instruction?

Teacher 2: I would say maybe 50%

Interviewer: Okay, question 3 what percent of your class time to students do something other than take notes and like what are they doing during that time? So in that other 50% like what's going on in your classroom?

Teacher 2: Okay. So, right now this is the first year that our school has piloted, I teach night grade and they have their own Google Chromebooks. So we use Google Classroom a lot where they're kind of like doing interactive things on Google Classroom half a semester course. So the first nine weeks is more like unit and like the structure of lecture-based and then the second nine weeks they focus on a big project that they're doing their own research for.

Teacher 2: And then creating a presentation that's 20 minutes, and they're basically becoming the expert on their topic and presenting that to a class.

Interviewer: Do the students in your classroom work alone talk to each other or combine to work together to test theories or do group projects or a mix.

Teacher 2: It's pretty much a mix, some of the stuff is individual some stuff they work with a partner, small group, the projects that they do they work with a partner or like a group of three if it's an uneven number in the class pretty much.

Interviewer: Do you ask students questions to seek a specific answer, call on students, or solicit multiple answers to critique and analyze as a group?

Teacher 2: I don't really specifically call out students individually, like, I obviously ask questions and if someone raises their hand, that's when I'll give students the opportunity. I try to give students the opportunity not only to answer but for other students to expands on a different answer. We also do like different kind of games such as like who or quizzes and things like that where like multiple students answer certain questions too. So and then like I'm kind of like getting like a broader spectrum of responses.

Interviewer: Okay, question 6 is about like when students do ask questions. So if they do ask a question in your class, would you say that it's often in the context of the material you're delivering or do they ever ask a question and another student answers, does that ever happen?

Teacher 2: Yeah, sometimes a lot of times. If they're asking a question, I would say more so I would answer what sometimes it does happen where maybe like another student will answer their question or like have a comment question her after I've answered the question.

Interviewer: Okay question 7 or students in your classroom. Are students are engaged in a learning environment that addresses different student needs? If so, what are some of those needs and how are they assessed and, how were you trained to do that?

Teacher 2: Sorry. Can you ask that again?

Interviewer: That would be a lot like would you say that like the setup of your classroom can address like different student needs so that these are like different styles or learning abilities?

Teacher 2: Yeah, I think so. You know some of the stuff I do is more. I guess you could say like old school with like the incorporation of like the technology as far as their Chromebooks and things like that as far as assessment we kind of allow the students to either use the Chromebook or use like a paper version. So kind of whatever they feel comfortable with because some kids depending on you know, some kids just like the test better on paper versus doing it on technology and some kids would rather do it on technology than paper. So we kind of give that option now as well.

Interviewer: Is that something like you feel like with the best practice based on your education or that's like a district tool thing?

Teacher 2: I feel like it's a little bit of both because I feel like right now like technology such a big thing with like this generation. So I feel like they have grown up with technology. And so I feel like by doing that and changing that is like starting to kind of like be the new norm because they're so used to doing so much with technology, but I think to now was with our district initiative this year as far as going One to One with you know, eventually working our way to one to one, I started with certain grades. I feel like it's now almost like okay, we're doing these one to one. So, how are you going to use this in your classroom to?

Interviewer: Okay, awesome, question 8, do you give instructions to your students prior to teaching a lesson, do you go over like learner goals, or do you kind of just like go into your new lesson?

Teacher 2: I kind of go into my new lesson but a lot of the stuff that I teach kind of builds off of each other. So a lot of times in the beginning of like new units, I'll reference back to things that we've done previously. So that's kind of like going over like the learning objectives plus like reviewing stuff and how it's like all Incorporated and like building off of each other.

Interviewer: Okay, that makes sense, question 9, do students engage in less in the lessons with different learning objectives? Like what do you use to teach in your class? And like how do you pick those resources?

Teacher 2: We actually don't in the class that I teach we don't have like textbook about a lot of my resources. I'm like researching online or like educational platforms or you know, current events or things like that or like Trends.

Interviewer: Okay

Teacher 2: So I kind of go like based off that kind of stuff and gear that towards you know with what I'm teaching at times, you feel like you have time to do that kind of stuff.

Interviewer: Do students participate in a variety of activities that are appropriate for the time allocated to teach the lesson?

Teacher 2: There are times where I feel like I do have to like breeze through and like just lecture and get through and then review and test and I feel like I don't have time to do other things that I would like to do or expand or projects on other things because there's a little time because I only like the class is only semester, like if it was a year-long class, I feel like I would be able to do a lot more and go more in depth and really do a lot more like interactive things or group projects and things like that. So I feel like at times with the time crunch it is like very difficult to do. So, but that you know, like I said, there are times where I do, you know, they do certain little activities or group projects or you know, just like a group activity for the day. I do try to break that up for them, but it does get really hard.

Interviewer: How are students assessed? Are you using a mix of formative and summative assessment techniques and instruments?

Teacher 2: Nothing that's really provided from my district, like everything that I kind of test them on is kind of what I've developed through like our curricula which two years ago, I rewrote the curriculum for our classroom. So, a lot of it is just things that I've created on my own it and it's pretty much both formative and summative and like I said, there are times where they will, when they do their big group project that they kind of like critique and grade each other, or I wouldn't say like it necessarily affects their grades, but it like provides feedback for them to have them like rate and discuss what was good. What was bad so on and so forth.

Interviewer: So, okay cool question 12 do students engage in various modalities of learning. So like discussion collaboration inquiry problem-solving predicting. If so, what is the most common and what do you think is like the most effective for student learning?

Teacher 2: I feel like they do all of those. I'm not really sure what I would say like the most common is though. It's hard to it's hard to say because with 9th graders like you feel like they should be farther than what like seniors are and they're not really quite there yet. If you get what I'm saying?

Teacher 2: Yeah, probably problem solving and things like that.

Teacher 2: Okay.

Teacher 2: Yea, because yeah, sorry.

Interviewer: Question 13. How do you insure that students are engaged in higher levels of thinking (inside or outside of the lesson)? What do you do to really make sure that you're driving home a lesson?

Teacher 2: I use like a lot of exit tickets just to like reiterate and double-check that they're like really getting like what I'm talking about that day, and I kind of use that to see if you like. Okay. Did I miss this? Did I miss something or am I not achieving what I'm need to achieve for that lesson. Do I need to read go over do I need to teach it differently like, you know, like, you know just to ensure that like they're totally engaged and they're you know getting and thinking. I do a lot of like I try to do a lot of application type thing so, you know, like for example, like I'll… one of the lessons I will teach and in order for that to understand what it is. Like I have a group project where like it will read different scenarios and have to answer questions based, and like applying what like the lecture was on till I can really grasp like, okay like what we're thinking outside the box like this is what we learned now can we apply it to that like higher level thinking

Interviewer: That's awesome.

Interviewer: Question 4. Do you ever witness student interactions in your classroom that you think give evidence of learning, like student-to-student interactions?

Teacher 2: Yes, I do just based off of like them talking, like an example would be like I taught a lesson and we watched kind of like a movie to go along with like unit. And one of the things that the kids did was while the movie was happening, like I didn't really even tell them to do this but a couple kids decided to say like hey, that's this or like this. And so forth until like, you know, they started like talking amongst themselves and like coming up with these things on their own based off like the lesson. So like I do here that you know interact and say those and talk about a lot of the things that we do discuss.

Interviewer: Okay, have student interactions ever negatively impacted one of your lessons?

Teacher 2: Yes, it can if it gets off topic and I mean it is kind of sad to say but it depends on the student and it's a student is kind of liked by their peers are not liked by their peers or if they're known to be someone that goes totally off tangent or off topic or is that kid that like constantly kind of like pushes the limit or wants to bring up something. Like that's like an attention-seeking Behavior. So then the kids, kind of other kids can become annoyed or distracted and that can like distract their learning.

Interviewer: So you see that you see that with students on the spectrum some time too, like not on purpose though?

Teacher 2: Yes. Absolutely. Yeah.

Interviewer: It's a problem in college. Yeah. So because like you can College like they're in classes that they're interested in, you know, like imagine student finally gets to super hard physics and they're just so excited. They want to know everything that is like derails the whole class.

Teacher 2: Yes. Yeah.

Interviewer: Okay question 15, and I only have a couple more, do the students track their own mastery of content in your class.

Teacher 2: No, I don't think so. What do you mean by that?

Interviewer: Like, there's nothing they could look at and say, oh, I understand this to that extent? So like it's mostly based on like their grades ..

Teacher 2: and like yeah, I feel like that's more like kind of college level. Yeah. Yeah. Yeah

Interviewer: Question 16, Are students provided examples of quality work through exemplars?

Teacher 2: Something a student did before them or a student in another sections, like examples from other students?

Interviewer: Yes, do they respond to that?

Teacher 2: Well, they do so when I do that most is when they work on their big project and like a second portion of my class. To like give them an idea because it's a really big project and it requires a lot of research. And like I said, I have to make a PowerPoint they have to present for 20 minutes and that seems like a really daunting and overwhelming for them. I don't know. When they have to do that, but they have to write a research paper and they have to create like a quiz or a handout for their classmates to do on top of it. And so all that can like seem like really scary for them. So I try to yo show them this previous work that like did phenomenal pretty much on that project to give you an idea like hey, this is what I'm looking for. This is what it looks like. This is how it should be set up, like here is an example like an exemplary student from previous years or previous semesters, you know, and this is exactly what I'm looking for. If and what you should strive for if you want an A pretty much. They do actually, a lot of kids especially the kids that really like want to Do well respond really. Well like they find that very they've said that they find that very helpful and it doesn't seem so like it's like they almost can't picture it in their mind when I'm explaining it and then once I show them that they're able to like okay. Yeah, let me see.

Interviewer: Question 17 is technology easily accessible and integrated in some, or all of your lessons?

Teacher 2: I would say that it's integrated in pretty much all of them because I'm you know, if I'm lecturing I'm doing a PowerPoint each day. Like I'm posting to Google classroom and there's assignments on thetr…not every day. But like a lot of the days. I find it personally, I find it hard sometimes to totally like utilize that or to go strictly like all technology like Google Classroom based because I feel like while, it's beneficial. Like I feel like sometimes like old school things as far as like copying notes are beneficial too, because of like the reading and the writing and the comprehension at that is proven like studies are proven with that. Sometimes I find it like difficult to always include it because I don't know that it's like my personal thing is I don't know that it's like always needed like every single day like shove down their throats.

Interviewer: Has technology ever like negatively impactED your teaching?

Teacher 2: Hmm every day. I was social media. Yeah, forgive me. Yeah pretty much because.

Teacher 2: You know, like there's nothing that's like not available to these kids anymore as far as like just a simple Google search or things like that. And so. So yeah, yes and with social media period and you know based on what it that you know, yeah, it does play a role.

Interviewer: Okay question 18, do students use technology to extend their learning beyond the classroom. Like is there like ever technology that like fills in the gap that maybe you didn't cover in the classroom or is it just like a way for them to do like a project and assignment?

Teacher 2: Yeah, it's I would say more of a way to like do a project and assignment, not necessarily. I mean there are resources that I do tell them about like if they are interested in learning or knowing more about a specific topic. Like I'll say like you guys can Google this and like, you know, or there might be something that like, I personally probably really don't have access to or can't go over with them like in class one because I don't have time or maybe. Maybe you know, it's something that they may need to run past their parents because it's like an iffy subject type thing, but they like it's great. If you want to watch it, you know talk to your parents about it. You know, it's not something we have time for can watch it here. But you know this this will explain this or go over this and so on and so forth. So I do try to do that sometimes but I would say that most of the time it's just for like more like research-based type things.

Teacher 2: Yeah, okay last question.

Interviewer: Question 19, do the students use technology to solve problems ever individually, or do they ever use technology to solve problems in collaborative teams?

Teacher 2: I would say more individually, but at times also collaboratively too based on whatever they're doing or whatever the assignment is. Okay, I would say like percentage-wise if you break it down, I would say it's probably more individually then collaboratively that makes sense.

Interviewer: Yeah and the last kind of thing that kind of goes with that. Were you like trained like for technology integration or is that something you feel like you're learning like as you go now?

Teacher 2: I feel like I'm definitely learning as I go especially this year like with the Chrome books because like I don't know what's on their end, if you get what I'm saying, like what they're seeing, and I'm like, I'm in the generation that didn't really grow up with this Google, all the Google stuff. So I feel like I'm like totally having to teach myself and learn that like as I go there wasn't really.

Teacher 2: A specific training that was provided or that I went through for it. And so there's like all these different things. Now, we do have someone within our district that basically is like solely technology-based and he's like we joke we call him our Google guy, but that's really not what he is, but right he's a resource that we can use that basically can take any lesson and find what we need for it or provide the extra support or come to our classroom and do different things like with our kids or he can like help us.

Teacher 2: So, last year we changed our, a lot of our health classroom over to the Google classroom, and he helped us do that and help me do that. And now he's helping with our projects like different extensions that Google has like that will help with their projects and things like that. So we do have somebody that does that but like I've never really received like legit training. I've just been learning and teaching myself as I go… which has been kind of hard. Yeah.

Interviewer: Yeah. I know that's kind of what I'm getting at with

Teacher 2: I feel like the kids are like the kids know more than I do and then I feel like stupid a little bit because I don't necessarily know but like they are.

Teacher 2: Do you know what I mean?

Interviewer: Yes.

Teacher 2: But like you're the one that's supposed to be like the teacher like the expert like I have no clue. So I claim that stressful sometimes.

Appendix F

Teacher 3 Interview

Interviewer: So the first question is what is the goal of your classroom? Would you say it to provide students with knowledge have students think about material during class or have students construct their own knowledge?

Teacher 3: To have students construct their own knowledge. I would say mainly I operate from a constructivist background. It does change, however, depending on the lesson or the goal of the lesson.

Interviewer: Question 2 what percent of your class you find yourself typically speaking lecturing offer and just like direct instruction?

Teacher 3: I would say about 25% direct instruction, with a mix of other methods depending on the topic.

Interviewer: Okay, question 3 what percent of your class time to students do something other than take notes and like what are they doing during that time? So in that other 50% like what's going on in your classroom?

Teacher 3: 25% of class could be categorized as note taking in response to my lecture, the other portion of class is characterized by group work, lab work, examples, group exercises or real world applications based learning.

Interviewer: Do the students in your classroom work alone talk to each other or combine to work together to test theories or do group projects or a mix.

Teacher 3: There is a mix of methods in my classroom. Testing and predicting hypothesis is common, as the lessons are a range of physics classes and topics.

Interviewer: Do you ask students questions to seek a specific answer, call on students, or solicit multiple answers to critique and analyze as a group?

Teacher 3: Being that it is physics, sometimes there is a right or wrong answer. I like to give students a problem with the steps laid out, but some of the steps are out of order or missing. I will then ask them to find the right answer which allows for critiquing or working in groups. My students are set up in pods of 4 and it lends itself to this.

Interviewer: Okay, question 6 is about when students do ask questions. So if they do ask a question in your class, would you say that it's often in the context of the material you're delivering or do they ever ask a question and another student answers, does that ever happen?

Teacher 3: A mix of these things. The questions can changed based on the content or the lesson. The questions also change based on the level of the class.

Interviewer: Are students are engaged in a learning environment that addresses different student needs? How are you trained/directed to address them?

Teacher 3: Are you asking about different learning abilities or different levels?

Interviewer: Both, or either, whatever you experience in the classroom.

Teacher 3: I teach a range from conceptual physics to AP physics. The way I deliver a lesson and the methods depend on those different learning styles and abilities. A lot of this training came from my first mentor and my graduate education program. I believe I am able to identify the needs of my students based on their performance and engagement.

Interviewer: Do you give instruction to students prior to teaching the lesson? If yes, are they informed of learner goals and how?

Teacher 3: Yes, for each lesson the learning goals are on the board before we begin and at the end of each lesson we may sure we have met the learning goals set upon at the start.

Interviewer: Do students engage in the lessons through various learning objectives and use a variety of resources? What resources are most typically used? What are some successes you have had with outside resources?

Teacher 3: Yes, some of the resources came from my mentor which I mentioned. I do edit and change them to fit the needs of the class.

Interviewer: Do students participate in a variety of activities that are appropriate for the time allocated to teach the lesson?

Interviewer: What are those activities (type)?

Interviewer: How are they selected?

Teacher 3: Yes, the activities changed based on the lesson. We work in 84 minute blocks every other day. The activities changed based on the need for lecture, lab, or simulation.

Interviewer: How are students assessed? Are you using a mix of formative and summative assessment techniques and instruments?

Teacher 3: I am starting to change how I do this, but I use a mix of assessment. My school does not tell me exactly how or what instruments I need to use. I used a mix of things that come from our books, or lab, or maybe an auxiliary aid I have found.

Interviewer: Do students engage in various modalities of learning (e.g., discussion, collaboration, inquiry, problem-solving, predicting, etc.). Which is most common? Which is most efficacious in advancing student learning in your opinion?

Teacher 3: Inquiry is probably the most prevalent in the class, given that it is a science class (physics). I believe this is effective in advancing student learning. It gives the students a chance to explore topics on their own terms to master the content.

Interviewer: How do you insure that students are engaged in higher levels of thinking, this can be inside or outside of the lesson?

Teacher 3: I believe that my students are engaged in higher levels of thinking outside of the classroom. I think this can be most seen in research projects or papers assigned outside of the classroom that allows them to push their knowledge and deepen their understanding of the assigned topic. This has not negatively impacted the lesson. Once while teaching a lesson related to velocity I changed how I presented the material and had to back track and undo that work and it did negatively affect the classroom experience.

Interviewer: Do you feel that student interactions give evidence of learning and assessment? Can you give an example of this?

Teacher 3: I can tell based on the behavior and questions in my classroom if students are learning, which can be an informal assessment. Or it may be a daily quiz where I can easily see if a student is mastering the content given.

Interviewer: Has it ever had a negative impact on the lesson?

Teacher 3: Not that I can think of.

Interviewer: Do students track their own mastery of content? Is there assistance from their teacher? How is that done?

Students can track their own mastery from the quizzes and the multiple methods of assessment. They do get feedback on their work and should be able to tell if they are on track or not. Physics relies on the building of topics and their understanding, I believe students know if they are not mastering the content.

Interviewer: Are students are provided examples of quality work through exemplars? What is the reaction to this?

Teacher 3: Yes, my students can often nit-pick at each other's work. Often times I will provide an example of an old test with the named blocked out and show how that student answered some questions. Students can be harsh on each other when viewing those exemplars.

Interviewer: Is technology is easily accessible and integrated in some or all of the lesson? When is it used? How do you determine what is used? Has this ever negatively impacted your teaching?

Teacher 3: Yes, we mostly use PowerPoint and iPad for books. Technology can be something as simple as a pencil to me, so it depends on how we are using that. A lot of that is decided upon from my own pedagogical training. There is no school mandate to use technology at a certain level. It is certainly encouraged but there is no level I have to reach. It has negatively impacted my teaching when it comes to the iPad as you can probably understand. I have now a classroom rule where if we are not using the books they have to be facing down so I can tell they are not using them. I am careful with this because I want them to be prepared for college and there will be a mix of textbooks and iPad work. They need to be prepared for a school like Duquesne.

Interviewer: Do students use technology to extend their learning beyond the classroom? How is that measured or observed?

Teacher 3: They do. They are supplemental materials offered or quizlets that can help them outside of the classroom.

Interviewer: Do students use technology to solve problems individually and/or in collaborative teams? How is that measured or observed?

Teacher 3: Students use technology individually and in teams. I observed this through their group work and lab work.

Appendix G

Teacher 4 Interview

Interviewer: Thank you. So jumping right in, question one. It's really quite simply, what is the goal of your classroom? Would you say, to provide students with knowledge, to have students think about material during class, or to have students construct their own knowledge, or some combination?

Teacher 4: I think a combination at the high school level. I teach high school biology. At that point in their educational career, it's kind of more about synthesizing their own knowledge and forming their own hypothesis, given facts. It's a combination of everything, but I think in my particular classroom and at my level that I teach, I try to get them to start synthesizing their own ideas and taking the basics to the next level. Does that make sense?

Interviewer: Yeah. Perfect. Question two. What percent of your class do you find yourself typically speaking or offering direct instruction?

Teacher 4: 100% I would say.

Interviewer: Okay. Question three. What percent of your class time do you think students do something other than take notes in your class? Do you ever do more activity thing or being that it's science is it really lecture based?

Teacher 4: No. The way that I teach, it's very structured. The first six minutes, I know that's a weird number, but I actually have a timer on the board. The first six minutes is review from the previous day, like an entrance ticket sort of thing. It's kind of just testing their comprehension from the previous lesson, kind of stringing it all together. And then I usually do about only 10 to 15 minutes of lecturing and note taking, and then the remainder of the class, which is about 15 minutes, is guided practice and independent work or guided practice and group work. Whether it be a hands on lab or just applying the knowledge to a worksheet. But never, very, very rarely, maybe a couple times a month, do I lecture the whole class.

Interviewer: Okay. Awesome. Question four, and you kind of answered this, do students in your classroom and work alone, talk to each other, or do they combine to test the hypothesis? What's that student interaction look like?

Teacher 4: Well, the way that the infrastructure is in my room is it's group seating, so it's four per group. Whether it is the warmup or like I said, those last 15 to 20 minutes of class, they're always working together if they choose to. I'll give them the option to work together, but some people don't learn best that way so sometimes if it's just a worksheet or a review, the student can kind of opt to work independently as well but I always give them the option to work as a group as well.

Interviewer: Okay. That's awesome. Question five would be, do you ask students questions in your class, are you like, were you looking for a specific answer, or do you ever call one student to listen to multiple answers and analyzing the group? What does that kind of look like if you're asking your students questions in the classroom?

Teacher 4: I try to think of my questions before the lesson starts. I do this thing called embedded questioning. I actually embed the questions into my lecture and into the labs. It's kind of like checkpoints for me, so that I know that they're accomplishing what I need them to accomplish along the way of the lesson. I often use something called hots, higher order thinking skills. It's not questioning, what did I say or what is the definition for this term?

It's more so, what do you think would happen if I did this? You know what I mean? So they're like higher order thinking skills type of questions that I embed in.

Interviewer: Okay. That's awesome. You just inadvertently answered the question I wrote so I'll circle back to that. Question six, do students in your classroom often ask questions or seldom, or if they do ask questions, are they in the context of your material? What is the question inquiry on the students look like?

Teacher 4: The mix of students I have pretty much every year, I have two classes of historically low achieving groups and then I have a couple classes of historically high achieving groups. It kind of differs between groups. But believe it or not, my lower achieving, just based on state standardized tests and things like that, that's what classifying them as lower achieving, they are more inquisitive. They aren't afraid to ask questions as much as those higher achieving students are. It kind of depends on the group of kids I have.

Teacher 4: But that's kind of what I noticed in the past. And the questions, the content, I think you asked something about the content of the questions. They usually do go with the lessons. I'll get a curve ball, an off ball question, they'll think about something they saw on TV and how it applies or they start talking about STEM cells. I get a lot of crazy questions on things they seen on social media and that influences them a lot in what kind of questions that they ask too, because science is big on social media now and there's all these things that they see and it kind of interests them. That kind of helps me in the classroom too, but.

Interviewer: Right. Yeah-

Teacher 4: I don't know if I answered that question. I kind of was all over the place, but.

Interviewer: No, no. That was helpful. I mean, we could probably go on forever, but there was a recent study that basically said scientific literacy is actually not in an upswing on this country, even though those conversations are happening on social media but they're not often informed. It makes sense that your students are asking about that.

Teacher 4: Yeah. They'll see little snippets on Facebook, or a Snapchat story about why Pluto isn't a planet and they'll bring that kind of stuff to me too.

Interviewer: Yeah.

Teacher 4: They can be all over the place with questions.

Interviewer: Of course. Question seven. Are students engaged in a learning environment that addresses different student needs? If so, how would you assess what the different needs of the students are? Are you trained to do that? Is that just like your preparation as a teacher?

Teacher 4: I'm also trained in administration, so I'm a very data oriented. I really, really look at the previous year test scores. I teach a lot of ninth graders, so I actually get their scores from their eighth grade teachers and how they performed on their science standardized tests in middle school to kind of see where they stand, and I use that. What was the rest of the question?

Interviewer: Basically, were you trained to do that? Or did you kind of pick that up on your own?

Teacher 4: Yeah. Sorry, I completely forgot what the question was. I take that data and I kind of separate them into groups, and it's coming in so I already have preexisting data on them. And then I do a lot of benchmarks and I also issue these things called CDTs, they're called classroom diagnostic tools. They're basically benchmarks, additional benchmark assessments to see where the students stand on the topics that we're going to be learning their ninth grade year, and it puts them in a category. And then from there I can target the groups that are strong and weak, and when I do group work, I can kind of seat them together.

Teacher 4: I can put a really strong student with somebody who's not as strong on a particular topic. I can move the seats around based on who can help who. Or if I think that particular class would do better if I kept all the students that really crushed the genetics portion of the CDT, I could keep them together and I can kind of isolate the students that I know need work on that so I can give them more time during guided practice. I've been trained in that and I have extensive data sheets on all that. And then I take their state standardized tests once they actually take the test at the end of their ninth grade year and I compare it back to their CDT tests, the benchmark that I issued, and it's always like right on. It's pretty parallel and it basically tells me how they're going to do on their end of the year test, that CDT. It's pretty cool.

Interviewer: Okay. Awesome. Question eight. Do you give instruction to students prior to teaching the lesson? Are they informed of their learning goals at any point?

Teacher 4: Yes. I mentioned earlier that I give a warm up at the beginning of every class. I also give an objective at the beginning of every class. They keep a science notebook, so they will record the warm up, answer, the warm up based on the previous day's lesson, and then they actually record. There's usually like three or four objectives for that day in that class so they know exactly what we're doing and why we're doing it. So yeah, I do that every day.

Interviewer: All right. Awesome. Question nine. Would you say students engage in your lessons through various learning objectives, and do you also use a variety of resources beyond your textbook? If you ever use outside textbook, outside resources, how do you pick them?

Teacher 4: Our district started this thing this year, it's called CK-12 textbook writing. The teachers actually adopt a pre-written textbook that's available on the CK-12 website. It's a free resource and we adjust it. We kind of arrange the chapters in the order that we teach the topics and we can link the topics and add details and add vocab words, kind of just a mash up and pacing of our own classroom. And we can adjust the textbook to our own classroom and cater it to how we teach. Could you hold on one second? I don't know if Stacy told you. I just had a baby and she just woke up.

Interviewer: Oh my God, I'm sorry.

Teacher 4: Okay.

Teacher 4: Okay, sorry about that.

Interviewer: Oh my gosh, go. No, that's awesome. The next question would be question 10. Do students participate in the variety of activities that you feel you have the time for? How do you pick what you're going to do in a class in your given time period, if that makes sense?

Teacher 4: Yeah. I've been teaching for seven years now and I can admit, my first year I tried to fit more into a class period than what was beneficial to myself and my sanity and the students for their own learning purposes. Kind of just through trial and error over the years, I've figured out what we can fit into one 45 minute session, and what worked and what didn't work, and what labs were kind of just a time eater versus something that was actually effective in getting the point across in the classroom. For me, it was just testing the labs and testing the things over the seven years that I've been teaching, and I found out what worked. And to assess the labs, I usually do a survey and the students honestly answer, it's a Google survey and they tell me this was helpful, this wasn't helpful, and that's kind of how I go about it.

Interviewer: Okay. Yeah that's great. Question 11 would be how are your students assessed? Is it a mix of formatives and summative, or how do you assess your students?

Teacher 4: I would say it's a pretty thorough mix. That warmup question every day is an assessment within the first three minutes of class. And that tells me, it gives me the green light to move on from the previous day's lesson or hey, maybe I need to review it before I move on because it all builds, science builds. I kind of use that as a check point. I do the questioning and the probing throughout the class and then I give unit quizzes and then chapter tests, usually paper pencil based. The quizzes are online based off of a thing called formative.com. It's a test. It's just on the computer. And I also do lab reports and labs and I grade them that way. And science notebooks. I'm big on science notebooks, and they get a grade for that too.

Interviewer: Okay, great. Question 12. Did students engage in various modalities of learning? Like discussion, collaboration, inquiry, prediction, problem solving, and if so, what do you think is common and most effective to your class?

Teacher 4: I think the engage in various modalities, especially when we get to the labs, I usually don't tell them what's going to happen as a result of the lab. It's an open ended lab and they kind of figure it out and come up with their own conclusion. Throughout that process they're being assessed on all kind of levels, not just that basic level. I can give you an example. We do like an enzyme liver lab where we pull the enzymes out of the liver and the students, we expose the enzyme to different temperatures, and I don't tell them that heat denatures the enzyme. They just kind of figure that out based on the reaction and that's just one of the labs I do as an example. Yeah, I think that they engage in all kind of levels.

Interviewer: Okay.

Teacher 4: Especially in those labs.

Interviewer: Yeah. That leads to the next question 13. How do you ensure that students are engaged in higher levels of thinking inside or outside of the lesson?

Teacher 4: I think a lot of it has to do with what we talked about before, those higher order thinking questions that I embed and are they able to answer them? Are they giving me the answer? Are they using that as a jumping point for more questions? If not, then I could see that through the answers on the worksheets. Another thing I do is I classify all of my quiz and test questions on the Charlotte Daniels or on the higher order thinking scale. Every question has a tag below it. Was this a synthesis question? Was this an evaluation question? Was, you know what I'm saying? If that makes sense.

Interviewer: Yeah, that makes sense.

Teacher 4: I don't give all low, how do I want to word this? Just basic questioning. They all have a higher ordered thinking requirement to them. Well, some of them do, you know?

Interviewer: Yeah. That makes sense. Question 14. Do you feel that student interaction in your classroom can give you evidence of learning?

Teacher 4: I think so.Yes, I think so. It's at the high school level, again, you have those students just based on their own temperament that kind of take a back seat during group work. Their personality sometimes will keep them from exhibiting their true comprehension and if they're really understanding, just because their temperament is to be shy or their temperament is to not want to work in a group. But, most of the time I can tell through the interactions of the students who are interacting that they do understand. I can gauge pretty well, I'm on my feet the whole time they're doing labs. I'm never at my desk, so I'm eavesdropping on basically all their conversations.

Interviewer: Okay. Yeah, that's great. Question 15, do students track mastery of their own content or do you assist them in that? How would a student kind of know how they're doing throughout your quarter?

Teacher 4: I would say that science notebook that we keep, it just basically is an archive of everything that we did for that unit, and they're able to track everything. I mean, everything is in there. There's nothing that we don't do in class that doesn't get put in the notebook, whether it be a worksheet, a lab, lecture notes. They're able to kind of keep an ordered paste tracking of all the activities we do. And then there's a system called Power School that once everything is graded they can access their grade for every single assignment that they completed through that program. And I usually, it grades within a week, no matter what it is, a test, or a worksheet, or a lab. They have access to that.

Interviewer: Okay, great. Question 16, and we're close to the end. Are students provided examples of quality work through exemplars. If so, how did they react to that?

Teacher 4: I think I know what you mean. I give them examples of previous students’ notebooks. I always keep a couple of notebooks from the previous year or even the year before to show them like kind of what is expected of them on my end [inaudible 00:18:20] that they go in to the course. And those notebooks are available throughout the year for them to view. And I also keep practice Keystone essay responses for open ended prompts from students from the previous year. And I allow the students of the next year to grade them and analyze previous students' work. It kind of gives them practice if that makes sense, looking at open ended responses and critiquing them because I think that's important to do in science. They get practice doing that too.

Interviewer: Okay, perfect. Question 17, is technology easily accessible and integrated in some or all of your lessons?

Teacher 4: In some. I can't say that it would be in all. It is accessible to almost, it is accessible. Now do I include technology in every single lesson, no I don't. We personally just, I guess for my own pedagogy style, I feel like I would be forcing it. At our district, how the students traditionally learn across all the other classes, there's very few classes in my district that are completely what's called flipped, where they include technology all the time. And the students, don't really take well to those designed courses, just from conversations and surveys that I've given them. But I do include it, I would say in more than half of my lessons.

Interviewer: How do you determine when to use it and was it ever a negative impact?

Teacher 4: Was it ever negative impact? I'm not sure yet to be honest. Our district just kind of got Chromebooks. They're starting a one to one, a thing where all the students would get their own Chromebooks eventually. And we just had access to computer carts in the past couple of years. I'm still integrating it. Formative, those are the quizzes that I give, they're online quizzes, it makes my job easier as a teacher because it grades the students' work automatically. But, some of the students don't really like the formative quizzes because they prefer a pencil based quiz. But was it negative overall? I wouldn't say it was. Virtual labs don't always fare as well as hands on labs. I've learned that in the past, where I try to include technology. Making a Petri dish and swabbing it, the kids think that's so much cooler than just doing it in a virtual lab online. I would say there would be the negative side of technology the way I've used it.

Interviewer: Yeah and they're seeing that in the chemistry side because combining two beakers is much less fun in the virtual simulation.

Teacher 4: Of course, yeah.

Interviewer: Okay. Question 18, do students use technology to extend their learning beyond the classroom? Is there ever a option to use technology to expand on a topic, or do you keep it centered with when you're doing it in a classroom?

Teacher 4: I think that the video resources that I can find online, and I do a Google class, excuse me, Google classroom, where I'll upload those videos to the classroom page and they can kind of watch them. I think those extend beyond what the lesson is talking about a little bit more and it kind of intrigues them a little bit more because it hits closer to what they're interested in. I've found YouTube videos that have pulled them in more than the textbook would and kind of extend beyond what the textbook has given them or what my lecture notes have given them. I would say the YouTube videos I can pull in, kind of take them a little bit beyond the classroom. Others than that for me personally, no.

Interviewer: Okay. That's awesome. And the last question, which is question 19, do students use technology to solve problems individually ever, or do they ever use it to solve a problem in a collaborative team? Or is the technology more just a way to replay traditional instruction and not a problem solving if that makes sense?

Teacher 4: Yeah. Okay. Honestly, you said the first option and then the second option, and then the third option. And I was like, yes, yes, yes.

Interviewer: Okay, so yeah, that makes sense.

Teacher 4: I think that they have worked individually, collaboratively in technology to form hypotheses and things like that. Now on the other side of the virtual lab, we've done like karyotyping where they had to figure out a patient X, what chromosome abnormality do they have based on the karyotype. I don't tell them it's open ended and then beyond that they would tell me the causes and the mute gens that could have caused the chromosomal abnormality. That's just something that popped into my head is something that we did with technology, but they work collaboratively. It was open ended, they took it to where they wanted to take it. We did some cancer research too on rogue cell division and the cell cycle using a virtual lab.

Interviewer: Yeah, that's great.

Teacher 4: They've done it individually, collaboratively and I think higher order thinking was involved on those.

Interviewer: I was a chemistry major. In 2004 and I remember doing karyotypes by cutting and pasting with glue sticks.

Teacher 4: And you know what, my first year I did that and it was like I said trial and error, it was awful. We used the chromosomes were the size of a pinky nail, they were all over the floor, it took three class periods just to cut and paste and that's just not time that you have in a public school. I know I ragged on the virtual labs a little bit before, but it depends because sometimes they are really helpful to me in a time crunch and logistically for them too. Yeah, we fell into the cut and paste trap.

Interviewer: Okay. That is great. That's my last question for you. Thank you so much for your time.

Appendix H

Teacher 5 Interview

Interviewer: Okay. Cool. So very simply, my first question, number one, is just what is the goal of your classroom? Would you say it is to provide students with knowledge, or have students think about material during class, or have students construct their own knowledge, or a combination thereof?

Teacher 5: I would say a combination. In a public school half the time you're working on many different things. You're also working with helping kids with day to day problems, like making sure they've been staffed so it's part content and part just helping a teenager get through their day.

Interviewer: Right. That make sense. Question two, what percent of your class do you typically find yourself speaking or offering direct instructions?

Teacher 5: What do you mean by direct instructions?

Interviewer: How much of your class is lecture, and how much is other stuff?

Teacher 5: It's really a wide mix because where I teach, they run double periods every other day and that's too long for 14, 15 year olds, ninth to tenth grade, to sit still. So we'll have discussion, we'll go over some information and then we'll do the lab or activity, while we're doing lab or activity, I'm monitoring around, I'll be walking around answering any questions. It's really a wide mix.

Teacher 5: A lot of schools now are doing those double periods in science because of the state Keystone exam. Kids have to pass that right now as a graduation requirement. So they're increasing the number of science periods, the time for these kids is really difficult for them to maintain their focus for that long.

Interviewer: Right. That makes perfect sense.

Teacher 5: So it's really wide mix to be honest with you.

Interviewer: Okay, awesome. So the next question is in your classroom, do your students, would you say they mostly work alone? Do they talk to each other? Are they ever in my group to like test the hypothesis? Like what does your student interaction look like?

Teacher 5: They're constantly working in groups, organizing ideas. Because of materials available they have to work in groups on labs. And there's only, part of the problem is class sizes are so big in science right now just because every public school tends to be given access.

Teacher 5: They have to share equipment and so they have to be talking to them. Even if they want to turn in their own paperwork, they still have to be communicating with their group, communicating with other people in class, working together. Things like that. Just because, it's hard for the classroom, I don't have a separate area so everything has to be done there. I have enough room where it's safe, where we have the materials out but kids can still move around and so kids have to work together.

Interviewer: Okay, great. Question five, when students ask questions to you in class, assuming that your environment allows for that, do you do call one students, do you ever solicit multiple answers or do they ask questions that are just totally out of the blue?

Teacher 5: What do you mean?

Interviewer: When your students are asking questions in class, are they related to the material? Basically what I'm getting at is can you track if they're understanding the material based on what they're asking you?

Teacher 5: You definitely can because depending on the types of questions you're asking, the type of answers you're getting, you can just kind of in the back of your head get an idea of the kids know what you're talking about or these kids are really struggling and they don't know the material. They ask questions about everything, they'll ask questions about general stuff that's happening in the room, they'll ask questions about what's happening in the school that day, and they'll ask questions about science. I mean kids in general are inquisitive. You'll get lots of different types of questions and then during class discussions I'll facilitate questions asking "what is the answer, what do I want to know?"

Teacher 5: And because a lot of kids now have high anxiety, I do things where there'll be sitting in their group, and they'll write the answer on the whiteboard, little whiteboards that each group has, and then they'll hold it up. And I'll spot-check, "group one and three, which looks good. Group four, five and six, let's revise that answer show it to me again", so that kids aren't directly targeted. Kids with high anxiety.

Teacher 5: That's a huge issue right now in public schools Interviewer, is the anxiety levels. Calling on a kid isn't necessarily the right idea now because just kids are so self-conscious and the anxiety the paperwork I have with kids with anxiety. They can't read out loud. Well they can't be called on individually. It's really, really a huge issue right now and so I do a lot like that where each group has a whiteboard. "Let's write down your answers. Everybody hold it up. Three, two, one let me see the answers and I'll just say like group one five, six your answer group seven eight that looks good." So they're participating, they're talking to their group, but they're not necessarily individualized as, "you answered that question and you're wrong", type of situation. You know what I mean?

Interviewer: Yeah, that's great. So, you kind of hinted that the students in your classroom would have different needs or probably different learning abilities. Do you think that's fair to say?

Teacher 5: Yes, very fair in public school.

Interviewer: How do you kind of access that informally? Were you trained to do that in your degree here or do you learn that as you went?

Teacher 5: I learned how to be a teacher from watching the teachers I had at Duquesne like John Doctor was phenomenal. He was my mentor, my research mentor, but he was an absolutely phenomenal teacher and I picked up a lot just by watching what he did and working with him. And I was involved in different teaching phases and I don't think I learned it at all from the school of education, to be honest with you. I think I learned it from the science professors I had and watching them. Content wise, no, I don't think I learned it and I don't think you can.

Teacher 5: I think to really be a good teacher you have to learn by doing and that's not going to come from a college classroom necessarily. It's going to be you in front of students working with a really good mentor that can help you. And when the class is over talk to you about "hey this, this was a good idea or this wasn't, here's how you can fix it". That's the honest truth I have about being a good teacher, it's really by working with other really good teachers and being able to work with them, and then reflect with them on, you know, what are some good ideas with what I did in the class, bad ideas and go from there.

Interviewer: Okay, great. Do you give your students ever prompts, or learning goals, or instruction prior to starting your lesson?

Teacher 5: Yes, every day we go over the objective for today is this, that it's written on the board. We go over that so it's posted for the kids see it many different ways because that's one of the big things you need to have right now. You need to have the objectives visible. So if a child doesn't hear you, they can also see it and it's written down and they're getting it multiple ways so that they know what the goal is and how they'll be assessed. Every lab there's a little rubric, every project there's a rubric, here's how you're getting your points that you need to do, those things are kind of general activities.

Interviewer: Okay, great. We're on question nine. You mentioned the students have probably a variety of different needs and you also have a lot of different learning objectives and you're using a lot of resources in the class. Besides the textbook, what would you say are resources you use the most and how do you find them?

Teacher 5: I make all my own resources. I don't use the textbook much. Kids in general are reluctant to actually go to the book. I use it as a resource, but I use and create all my own materials. And it's based on experience. What I know works or doesn't work.

Teacher 5: We use Google Classroom is utilized so kids, if they're absent, they can go back, look at what they missed, but in their room. I'm working mainly with all my materials. Things that came from the textbook publisher that I modified based on student misconceptions and things of that nature. Every unit I create what I call biology notebooks, so that unit that has papers that we're going to complete our notes, and so I'm not wasting any time throughout the day passing out papers. I'll say, "all right, let's go to page five. Here's what we're looking at today. This cell matching activity". We'll go over the directions and then kids will get started. Things like that, and that's pretty much where it's at.

Teacher 5: A lot of the labs and things that I've worked on with mentors of mine in the Pittsburgh area that were involved in science that I knew that helped me design things when I first started teaching. Stuff that I'm modifying constantly, but very few things I use comes directly from the textbook or directly from the publisher. It's more all stuff I'm creating now on my own.

Interviewer: Okay.

Teacher 5: I don't like a lot of what I see in education, how it's created. I think the problem is a lot of the stuff that's created for kids isn't created by teachers. It's created by people more on the business end or on the political end of education that aren't in the classroom. So it doesn't as well in the classroom.

Interviewer: Okay. Yeah, that makes sense. Question 10, so you mentioned that students do a lot of things besides just listen to you lecture and being that your classroom is so varied, I'm sure you could talk about this forever, but maybe in one double classroom period, could you walk me through some of the things that would happen besides you lecturing?

Teacher 5: Like double periods I don't lecture at all. I save that for the single periods. I'll lecture for 20 or 25 minutes and then they'll do a little activity. I teach ninth and 10th grade. So very rarely will I lecture longer than 25 or 30 minutes just because of the attention span, and in double periods, kids would come in, they'll look at what's on the board, the whole objectives for the week. I keep them up there. What's due every day and what we're doing so that if they're absent they kind of know what they missed and what we'll be doing the following day. After we go over all the general information, I do like a tidbit in science, something that is interesting that I came across in the news about science and then we jump into their lab or activity.

Teacher 5: Double periods are constantly moving because that's 84 minutes. That's a long time for 30 kids in a room to sit still and be able to digest some material. So we'll do a lot of little labs. Although we'll go over what they're going to do in the lab, I'll show them some different images or videos or whatever I need to with the pre lab. Then they'll jump in and they'll get their lab supplies. I set them up by stations. I have 10 stations and they'll pick up their brain bin and have all their watch supplies take to their seats. They'll do the lab. While they're doing the lab, I'll walk around and monitor and answer any questions for each group and then they'll wrap the lab up, turn it in, and then I always have something if finished early. You can do X, Y, and Z, and there's three or four things each week I have, because kids finish at all different times because it's such a wide group in a public school.

Teacher 5: Some kids will fly right through and they'll finish and so half of a second period to do whatever. Some kids it will take the full double period. Some kids even might have to take it home with them to finish, especially if it's a child with some type of disability, then they might need to take it home to finish. So I always have different things that they can work on. Plus in my room I have I call creation station, where it is science games and puzzles that they can work on any time if they finish things early so that everybody's constantly doing something, constantly focused on science because one of the big issues is cell phones with high school kids. They'll constantly try to access their cell phone, text their friends, and so I try to keep them constantly moving, constantly busy so that there isn't any downtime at all in the 84 minutes and it's really hard. It's like a juggling act. It really is like being in a circus.

Interviewer: Yeah, I mean that's impressive.

Teacher 5: And I do, I have labs every other day, so I'm doing this three times a week. I mean, it's just incredible what I'm doing. The amount of paperwork and the amount of planning I'm doing outside of schools. We've moved to these double periods every other day, it's just unbelievable. I'm in the building an hour before school even starts trying to set these up. We'll do two, three labs in one week with these double periods and it's just, it's unbelievable the amount of the time commitment. I think that's a problem, one of the problems with kids is teachers that are coming out of college just are not prepared to walk into a classroom with that kind of setting and that kind of work expected of them right away when they're starting out and that's how it is in science now.

Interviewer: So yeah, I keep hearing that over and over. Going along with that question 11 is how do you assess your students? You know, a mix of formative and summative from what I'm hearing...

Teacher 5: I'll grade probably a thousand papers in one week easily. Easily. And they'll have anywhere from 500 to a thousand points in nine weeks. I, because of the way things are, and the restrictions you have in public schools, I grade them on absolutely everything. There'll be graded on tests, quizzes, homework, classwork, activities, projects, labs. And so at the end of the nine weeks, it's a really well rounded assessment of how that child's doing in the class. And it is not, you know, if they're not good at tests, so they didn't do well or they didn't do their homework, so they didn't do well. It really is a wide mix.

Teacher 5: And I do that in part to cover myself so that if parents have a concern about how their kid was assessed or the administration. I am very, very thorough and it is very clear that if a kid failed my class they pretty much did nothing and everything. Like every little piece that I grade they did not perform well on. It's nothing where like a kid's bad at test so they failed the class, that does not happened at all in a public school at least where I'm at. It's such a wide mix. So it's a very fair grade of the child because especially in science. They have to, I think they need to be able to do hands on skills. I teach ah, live intensive classes, so I'm not looking for kids that can just memorize facts and plug and chuck them back. They need to be able to apply them, they need to be able to show me applications of phones, different ways that they can communicate about science, not just paper-pencil, speaking and working, all that stuff.

Teacher 5: Because, I mean, part of my mission is I think science is about, you know, doing things and being able to get into a lab and be able to work with other people, communicate results. Also be able to effectively write about science, and then execute labs, and also be able to prove that you know your knowledge in different paperwork that you hand back to me. So I look at them in many different ways.

Interviewer: Okay, great, you kind of already answered this question 12. Are the students in your classroom engaged in various modalities of learning, so discussion, collaborates. And problem solving an inquiry. I know that's, yes...

Teacher 5: It's a little bit of everything. Even in class discussion sometimes, like I did this ball game where I'll tell everybody to get up, we'll form them a circle, the room, I'll take a foam ball and say, "what do we remember about the cell?" And we'll start tossing it, and every time a kid catches it, they give me some information that they remember about the cell and I'll put it on the board and a concept map. Then I'll say, "all right, let's all sit down. We've done this for 10 minutes, let's start talking about these details", and then we'll start our class discussion and going through it and then I might say, "you know what? We still have 10 minutes, let's get up. We're going to do this matching activity, or we're going to look at cells under the microscope". It is such a wide mix to try to hit and target every single kid in the classroom. That's the key is it's every, it's about every kid, every day.

Interviewer: And so which of those things do you think is most effective in advancing learning? Or does it depend on the topic?

Teacher 5: Kids typically like the hands on stuff the best, where they're actually working with our friends, doing the labs, exploring the ideas, handling the equipment, because that's stuff that's new that they necessarily haven't done in other classes. Because the amount of time it takes to prepare these labs and this hands on stuff and be able to execute it, it's really hard to have teachers do that. And so I think at my class, kids really enjoy the amount of hands on engagement they're having.

Interviewer: And so all of that is basically your way of ensuring that like those higher levels of thinking and processing going on there.

Teacher 5: Yes. And the kids are taking ownership of their own learning. Like there's doing science, they're running their experiments, they're seeing their results. It's not just me telling them in an experiment you get results. Well they're actually finding their own results and discussing them and working them out and figuring them out and asking the right kinds of questions.

Teacher 5: And it can be modified for different levels of learning. Like if I have a kid that's lower functioning, they might only be able to do the lab and that might be it for them. But if I have kids that are really high level, I can walk around the room and ask them some more advanced questions that tie into that lab. So it's a way that I can also differentiate my instruction.

Interviewer: Okay, great. And so our question 14 really is just kind of simply, do you feel that when you're looking at your students interact with each other, that gives you evidence of if they're learning, can you give an example of something you observe and you're like okay, they got it.

Teacher 5: Well, as soon as they start their labs, I start walking around the room. While I'm walking I might not even be asking, I might be asking questions. I might just be kind of walking through observing what they're doing and I'm listening. Unless they were they typing about the lab, are they analyzing the results? Are they asking the right kinds of questions or are they completely off topic, in which case, and I'm going to stop readdress, here's what we're supposed to be doing, what you doing? And so there's definitely a lot of different ways that you can look just by walking around the room and listening with what are you talking about? Is it on topic? Do you know what you're doing, et cetera? And those are all skills that come with time.

Teacher 5: So I think that's part of the problem in a lot of schools when you have younger teachers that aren't from experience, they might be more hesitant to do those types of things and might focus more on stuff that's coming directly out of the textbook and not the lab engagements. Literally moving around the room and listening to kids talking about science.

Interviewer: Okay. Yeah, that makes sense. Out of question 15 do your students ever track their own mastery of content?

Teacher 5: What do you mean? Give me an example.

Interviewer: Like other than your grades you're giving them, would there be a way for your students to know if they're on the right track or if they're getting things correct.

Teacher 5: Okay. What do you mean? Do you mean besides giving them a grade?

Interviewer: Yeah, is there a way that your student in the middle of one of those 20 minute blocks that your student would be like okay, I got this, like I'm getting it, but do you give those prompts every so often? Like check for understanding, those types of things.

Teacher 5: Oh, daily they go through that. We talked about the objectives like at the end of class, this is what you should know. Then we'll go back at the very end of the period. Let's go back to the objectives. These are the goals. How do we know if we did well? Google Classroom too. I'm not sure how familiar you are with it.

Interviewer: A little bit.

Teacher 5: It's kind of like Blackboard that you can used to use. It's just a different server and in the Google Classroom, I post all the time. Extra practice problems, extra prompts that kids can try and check their work, and I post the answer and a solution, so that's if there is a kid that's struggling, they have a lot of extra resources, they can get immediate feedback and I have them do those all the time. I posted on there a ton of examples for practicing that they could look at labeling the cell and the answer keys and how to go about doing each question and analyzing it so that if they are having trouble, not only are they seeing the right answers for those practice things, they're also seeing the solution for how I got those answers so that they know what they might do wrong. Those things aren't assessed by points. They're just extra practice. So some kids will do them, some kids might not, but they're available to all the students.

Interviewer: Okay, awesome. Question 16 are your students ever provided examples of quality work from other students?

Teacher 5: Yes. I constantly hang up, work in the room. My space like is covered with posters, models, labs and then the cabinets, I leave free for student work. So anytime during something that they turned into me that is like a lab. For example, they did a pH lab at the beginning of the year and they had the color coded pH scale and throw it on a pH scale. Really good ones. I take the students names off of them because of confidentiality reasons, but I'll post at least one example from each class. See, kids can see what the other kids are doing and I'm that way and so kids too, you know, have some pride in their work. Like, hey, you know that's mine. It made it hung up. It hung up there. I don't keep their names on anything that I hang up, but I hang up examples from every period I teach of anything that we do. We did a water cycle diagram, where they create a water cycle using six or seven different terms and create their own setting. I hung those up. They did a condensation, dehydration reaction model, paper reaction model they put together. That was hung up. They just got done doing cell factories, looking at a cell analogy and it was an activity that I hung up.

Teacher 5: Labs and writing statements. I'll put some examples on if it's a really difficult lab like I'll put, here's an example of an analysis paragraph that was well done. This one received five out of five points so that you can get an idea of why you might got it. You might, you might've received a score you did. Everything I graded there's why I also correct, so if I take any points off, I explain to the child why I took the point off. I don't just mark the paper and hand it back to him. I'll explain, you missed this one because of this or this or this, so that when they get it back they can read over that and start to improve. It makes grading a lot more difficult just because of the time it takes to grade papers. But it gives each child individualized feedback on the work that they submitted to me and I think that's important.

Interviewer: Okay. Yeah, that's great. Question 17 and would you say your technology is accessible and integrated into some or all of your lessons?

Teacher 5: Yes. We are a one to one school district where I teach, so kids get an iPad because they can take home with them. And they have access to the textbook, access to Google Classroom. I put for all my labs and discussions, I'll put annotated notes on Classroom. That Google Classroom that they can pull up right in front of them. So in my class I utilize technology daily. You know, it's a really important resource. Especially with absences, because then if kids miss a lab, they can go online and I'll put up images of what we did in lab, like the makeup pieces and things so they can catch up pretty quickly without getting behind because again, I teach a class where it's a Keystone class so kids are required at the end of the year to pass the biology Keystone exams and so I have to make sure if a kid's absent, they have access to all their material and then at the end of the year all the kids can go back and review anything that they need to test.

Teacher 5: Those state tests have really put a lot of checks and balances in what has to be done and available to kids throughout the year.

Interviewer: Okay. It has. Do you think technology has ever negatively impacted your teaching?

Teacher 5: Yes. When we first got the iPads, the one to one initiative, kids could access video games on their iPad and right through the system at Chandler and access games and some of that content. And that was a big problem for a long time. Our tech people now are blocking out certain things so that kids, there are certain things they can't access on the iPads and that helps a lot because then the iPads only for the school stuff and then that's not a huge concern anymore.

Teacher 5: The first year with the iPads, they were getting into all kinds of stuff online they had no business accessing during class. And then they were paying attention to what was happening. So I think with technology it is true because if you just give a kid an iPad and they're in the middle of their class, they're not necessarily going to look at stuff just for class. They're going to be on YouTube, they're going to be playing computer games, they're going to be on Amazon and do all kinds of stuff. And so we really had to institute how the iPads were used and what the kids could access while they went to school.

Interviewer: Yeah, that makes sense. So were you ever trained to integrate technology in your lessons or is that something you picked up along the way?

Teacher 5: They, I mean, districts do train, but I don't think it's effective. I learned everything that I needed to from just teaching as I go. And that's really difficult because it puts more on the teachers. I think teachers, in general, a lot are bogged down already, we're doing and they just don't have the time to commit to that. And so what you're seeing is sometimes, you know, there are teachers that aren't using the technologies and aren't making strides and using the technology. But the world in general is where kids are at right now technology's a big part of their life, but at the same time it's a really tough balance because a lot of the training available to teachers in technology is very poorly done.

Teacher 5: And there aren't a lot of resources when the teacher's in the classroom. But so the hope with integrating the technology to their specific needs in the classroom. And so a lot of what I've done, I've had to learn on my own kind of a trial by fire, which has put, which has made it more difficult, but at the same time gotten me to the point where I can help a lot of other faculty members that I work with, with technology and how to utilize it in their classrooms. So that is nice, I can collaborate more, not just with the people I work with, but at the same time it's a lot of work to try to figure out the technology. We do have a tech person where I teach, but we have one person that's responsible for 1500 students plus a hundred faculty. So it's sometimes difficult to be able to reach them and really get the support you need. And that's why a lot of times you are on your own to utilize the technology.

Interviewer: Yeah, that makes sense. So would you say that the technology ever served to extend student learning beyond the classroom? Or do you think...

Teacher 5: Oh absolutely. I think it's helps kids outside because the Google Classroom, they can access that anywhere they want, as long as they have internet access. And then they could take notes and save it in the app Notability and then they don't have to have the internet to use. They can access it even if they don't have internet access. And so it works out really nice. Kids can have resources to help them, whether they're in your classroom throughout the building, or at home working. And it also helps parents. Parents that want to help their kids, but aren't necessarily really strong in a subject, can utilize the resources in the Google Classroom and then know that they're doing. Parents can also latch onto your Google classroom page if they want to see what their kids see.

Teacher 5: And so learning can happen anywhere at any time. I've had kids that have been out for extended reasons where they've missed like a month or two, but they've been able to follow along on Google Classroom to know exactly where we're at each day so they can come back in.

Interviewer: Wow, that's amazing.

Teacher 5: It's really nice. Like I had a young lady who for mental health reasons had to go into another institution and while she was there, there were people in institution to help her, but they could access all my Google classroom stuff so she could see what the other kids were seeing. And when she came back and was healthy again and was able to come back to the regular school, it was like she never left and it helped her. She just kind of eased herself right back in.

Teacher 5: Some of them might miss a whole week and so while they're at home, they can look at their, they can use their iPads that they get from the school, or their computer at home. They can kind of see what we're doing and then when they come back they can jump in, and so it helps a lot with their anxiety. It helps them catch up faster. It helps the parents because they know their kids have some things that they can do and they can look at while they're out and then they can just kind of work at their own pace. So I think it's very nice in that sense.

Interviewer: Okay. So my last question, 19 would actually just be, do students in your classroom ever use technology as part of their problem solving process in the lab? I'm assuming you use a pH meters and stuff like that, but is technology ever a part of a problem solving exercise?

Teacher 5: Sure. There's sometimes we use, they're called gizmos. I don't know if you're familiar with the Explore Learning site. It's set up for high school and college kids, mainly high school. They're a little lab simulations, so sometimes they fit to a lab. I don't have the materials in or it's a lab where it's just not feasible. We'll do the gizmos, and there are online lab simulations that use real time data that kids access and get. An example is I do a chicken genetics one on codominance. I can't really have a chicken coop in the classroom or raising chickens. That's obviously not going to work. But this gizmos, the kids can monitor chickens and it's an online simulation and get the data on to the different chicken patterns that are inherited and analyze data, working through this computer program. That's an example of a type of lab that works out really well using technology.

Teacher 5: There's other things too, like sometimes in their lab, like the water cycle lab. They had to put together an example of a water cycle simulation diagram. So a lot of the kids are using stuff online, just try to look up the different terms and what they meant. It was a redo lab because they've had the water cycle in elementary, middle school, but they might've forgot it. So they'd it use it to look up different things.

Teacher 5: They're constantly using the calculator on the iPad to do their calculations, so I'd say yeah, there's a lot of it can be used and used well in a classroom, especially in a science classroom.

Interviewer: Right. So thinking about how you and I were trained in high school to learn science, and even at Duquesne. Do you think that technology is available to a point and size that students are able to do or tackle a topic they never would've been able to do before? Like it completely transformed, you know, because I talked to another teacher and they were doing karyotypes online, but I think about in gen bio, how we cut and pasted them together.

Teacher 5: Yes, I do. You have to be careful though.

Appendix I

Teacher 6 Interview

Interviewer:	Okay. Jumping right in. The first question would be, what is the goal of your classroom? Would you say it's along the lines of providing students with knowledge, having students think about material, or having students construct their own knowledge?
Teacher 6:	I think it's going to be a mix. The goal first obviously is to install knowledge. You've got to kind of figure out where the student is. Like, what do they know about what do they know? I think that's your first step. I think you really have to work on the idea there is the connection to what you're accomplishing, what you're trying to accomplish, circularly what do you consider your level of mastery, what do you need them to accomplish and what are you going to accomplish overall. Direct instruction is not always going to meet your needs, nor do I think it's always the most effective choice. So, I see my classroom as a mix of all different types of features.
Interviewer:	Okay, awesome. Question two. What percent of your class do you find yourself typically speaking or offering direct instruction?
Teacher 6:	In terms of day to day, I see myself offering direct instruction I would say most likely three to four days, five days a week depending upon what I am doing. Especially in the beginning stages I want to get out some, my voice

is not the only voice. There's a lot of information students want to share and already know, so it's very, very important that it's not just educator fulfills knowledge and students are just there as preceptors of knowledge that students really have a chance to benefit and share what they know. So I don't want to be the only one just talking in the room.

Interviewer: Okay, great. So for that percent of class time that students are doing something other than responding to your lecture, other than taking notes, like what percent would that be and what activities are students doing if they're not taking notes?

Teacher 6: I would say probably about 30%, 25% to 30% somewhere in there. If we're not taking notes I want to be interacting, I want to be writing, I want to be doing. So whether they're doing independent review, whether we're sharing their knowledge orally, they're independently reading, I'm individually meeting with students while they're working independently on a task. I try to keep it as different every day as possible with the constraints of again, going back to what's my level of mastery and what do I want them to accomplish and what's achievable with each student because each student is going to come up with a different level of mastery.

Interviewer: Okay. Awesome. Question four is kind of about student interaction in your classroom. So would you say that students in your classroom work alone or they talk to each other or they decide to work in a group? What does that look like?

Teacher 6: We're talking, everybody's talking, and I think again it comes to the idea that if I'm talking I'm gathering a lot of student feedback, like whether we're sharing in a just conversational way or if it's this formative assessment, like we're talking about, did you understand that, can we really put that into application? And then working in small groups and a large group, pairs or small groups depending upon what the process looks like and the activity that I need to accomplish that day.

Interviewer: Okay, great. Question five. If you ask students questions in your classroom like looking for a specific answer or are you calling on students to spark debate or critique as a group, like what does the inquiry look like in your class?

Teacher 6: I do. I find myself asking questions, especially when you're in the idea of interpretation, when you're trying to analyze, what does this mean to you? What does this mean? Because again, I'm not just the only information highway in the room. Other students can have viewpoints that are developed, albeit they might not be exactly what I maybe anticipated, but I'm pretty flexible with let's roll with it. I want to hear what you have to offer, I want to hear what you're sharing here. I say that it shouldn't be just me doing the heavy lifting here, you guys, this is your time to gain knowledge,e so let's make good use of that time.

Interviewer: Okay, great. So question six is kind of the flip of that. So do students in your class ask you a lot of questions and if so are they in the context of your material or do students answer other students' questions? What does that look like?

Teacher 6: I think it starts off with just asking me. I think especially in the beginning weeks when those relationships are just getting formed. But I think now we're at the point where we're 11 weeks in, students are asking other's questions. They know my expectations, they know my level of what I'm looking for and also it might not be relevant what we just covered, the material, but it might be a question that is just overall connected to another concept level.

Teacher 6: Like how does this apply to this? Or I can see how this fits together now with science, social studies, world language, whatever it may be, math, they typically can all lay on top of each other and create connections. Each student's connections are going to be different again from what I even thought.

Interviewer: Okay, awesome. Question seven is, would you say in your classroom students are engaged in the learning environment that is addressing different needs? If so, what are some of those needs and how are they assessed and how were you trained to deal with that?

Teacher 6: Hm-hmm (affirmative). I definitely think that my classroom addresses different kids' needs. Every student has a different educational need, whether they educationally are achieving, without documentation, IEP, service agreements, a type of core plan, whatever that may look like, but each level, each student has their level that they can accomplish. So I try to make that here's the bar, here's the testable content, here's what we need to do, and we'll try to make this as user friendly as possible. Let's put this in application of either your real life, your everyday working, what does this look like and how does this apply to you, and why should you care as a student of what I'm talking about. It's not just, this is the content, learn it, take the test and then we're done with it. No, we're constantly going back and I'm doing a lot of spiral review throughout the nine weeks, throughout the year. And that's has always been my viewpoint that nothing lives kind of in a cave by itself. You always have to connect back to previous connections to build content.

Interviewer: That's great. How were you trained to do that? Was that something you picked up or was it in your education training or just part of your pedagogy?

Teacher 6: I think it's something that I've truly picked up along the way. I don't think I can refer back to a class that I actually have learned. I think when you begin teaching, I think the pedagogy of learning at university is 100% great. But it's not every day, it's not what everyday life looks like. So you really have to kind of put the pedal to the metal and see once you hit water what can your students do, what are they engaged in and how do you connect to that? So I think to me it's just been more what I've learned in the field.

Interviewer: Okay, great. Question eight, do you give your students instruction prior to starting the lesson? Like do you start with learner goals or objectives, or do you kind of just jump into your topic or does it depend what the topic is?

Teacher 6: I jump into the topic. I'm typically am going to go set the scene, just because my own attention span is short. I like to let kids know where we're going, where we're heading, so I talk about it maybe the day before, like tomorrow we're going to connect, this is going go to this or wrapping this to this, connecting to this. And then I typically start out with talking about the learner objectives, like what we're going to be doing today, what we're doing overall, what our big goals are for where we're heading, just so they're fully aware.

Interviewer: Okay. So the next question would be question nine. Do students engage in the lessons through various learning objectives and use a variety of different resources besides the textbook? If so, what resources do you also use?

Teacher 6: No, we don't have a textbook. I don't use a textbook. I go with the resources that I create or create with other teachers in terms of what testable content is. That's what I use. I pull from a various amount of resources for when I'm teaching. I don't have a kind of easy bake oven, if you will, of pre-made lessons or stock.

Teacher 6: It's teachers working together to talk about what do we need to get our kids to do, where are we going in the scope and sequence of this year we need to accomplish this, this unit we need to accomplish this, what are we doing and how are we getting there? So I have a lot of good flexibility to pull full resources as much as I want, and try to make things as exciting as possible. I'm not looking to be some park of education but I'm looking for something that is going to keep interest, what's going to satisfy students' needs, what's going to keep them engaged for a 47 minute period and what makes them want to come back and talk about the class, what are they sharing at home? That to me is huge because I could teach all day long, but it has to be something that they can master and they can talk about in their own lives.

Interviewer: Okay, great. And you mentioned the period, so in one period of your classroom are students engaged would you say in a variety of different activities? What activity types happen in your class and how do you pick what you're doing?

Teacher 6: They are. Each day is a little bit different. I look in terms of looking at what is my students' content knowledge? What are my students able to do thus far? We spent a lot of time and it's a skill that benefits all skills, reading comprehension. So what if I'm annotating texts? Reading text together? Let's make meaning. There's things that I'm a little bit more heavy handed in with let's talk about this, let's break this down, especially when we're looking at implicit meaning and that's a challenge for all students. It's depending on, no matter what grade level or age level, implicit meaning is tough.

Teacher 6: So I'm looking to give them kind of as we go through it's a scaffolding of information. Like, that first couple of weeks, the first nine weeks, I'm driving the car the most and then slowly as we go, analogy wise, I'm taking my hand off the wheel a little bit and give more room to drive their own learning and drive their own note taking and knowledge creation, because again, I can do this all day long, this is what I'm trying to do. What they know I need to train them to do is become independent thinkers and start taking ownership in even small ways.

Interviewer: Okay, great. The next question is, how are students in your classroom assessed? Is it a mix of formative and summative assessments? How do you choose to do your assessment?

Teacher 6: I do a mix of formative and summative. I probably do more formative than I do summative. I think summative is great, but I don't believe in gotchas, especially with my level of students, the level of home support that students have. Working in education I've seen this change dramatically over the years. I think summative assessment is great. But I want to make sure that these summative assessment pieces are not pitfalls. Like if a student doesn't do well on their assessment, this is a nine weeks ender or a grade ender, whatever it may be, [inaudible 00:14:13] something that destroys their confidence in their own abilities. So I tend to do more formative. Summative I still do, I probably do, I would say probably five and under summative pieces a quarter.

Teacher 6: But I'm flexible, based on what my needs are. I like to go back and do a lot of formative stuff because, again, I don't think anything lives separate. So I'm going back to talking about anything that I think is relevant to testable contents, grammar concepts, knowledge concepts, how to annotate, how to look for key words when we find vocabulary in text that doesn't make sense for us at our knowledge level. Because again, I see the benefit of summative but I think we have to build more, especially at our level, before we really start giving big summative assessments.

Interviewer: Okay, great. Would you say that your students in your classroom engage in various modalities of learning? and it sounds like yes, from everything you've said, but including discussion, collaboration, inquiry, problem solving, assuming that the answer is yes, what's the most common, and what do you think is the most effective in advancing learning?

Teacher 6: I use a lot of technology integration. I use technology for I'd say probably four days a week. Whatever it may be, I try to engage as much technology. We're one to one iPads, so let's make use of those as well as those can be really, really helpful. I think the most important in terms of that I've seen move the bar is the spiral review of concepts and then individualized check-ins or a review or personal editing or personal comprehension sessions like, well let's sit down and just read together, individually, while other kids are working on X or Y, let's really sit down and just show me what you can do.

Teacher 6: Because that's when it becomes more powerful for students and I can give the other students some time to work on something. It's still relative, but what we're selling right now, what I'm selling is, I really want to know where my kids really are. Not just what they can tell me on a test, show me what your skills are in front of me.

Interviewer: Okay, great. Question 13. How do you ensure that students are engaged in higher levels of thinking? So that can be inside or outside of your given lesson.

Teacher 6: I think it goes back to the idea of, you take the training wheels off as you go. When things get implicit, you have to let them do a little bit. You have to let them sit in that thought process. I think, instead of it being, especially when you start to get to that implicit part, let's do some writing, let's do some talking about it. Let's do it a little bit more individualized, because there's going to be kids that are going to wait. That implicit knowledge building is tough. So they're going to wait for people to be handing them the knowledge, and that might be okay for right that second, but what you need to be going into is that there's more independent thought pyramid that we're getting our students to really talk and write about what they understand and how this applies to the bigger picture of the concept level.

Interviewer: Okay, great. You talked about a lot of group work and activities in your classroom. So do you feel that student interaction can give you evidence of learning and help your assessment? Do you have an example of that or has that ever been like a negative impact on your classroom?

Teacher 6: No, I think it's always great. I think it's those teachable moments. I do a lot of grammar corrections with my kids, just because that's part of job. So when they correct each other's grammar, whether it might be something stupid about, can I, may I, whatever it may be, can I do this? May I do this? That's good stuff, because they have accomplished. I might have not hit directly instructionally, but they've heard me use it and they've heard me correct it and it's made some type of educational hook in their brain that they want to share out.

Teacher 6: There's a lot of kids, especially when we get to now we're in more, more and more implicit, where we are in the curriculum right now, that they're doing a little more heavy lifting. But I'm no longer jumping in and saying, if there's silence, I'm going to let silence happen. If it doesn't feel right for me I might not, but I'm going to let them sit and talk. What do you think it means? What are you getting from this? Because again, I should have a great viewpoint and I'm not the alpha and the omega in terms of interpretation.

Interviewer: Okay, great. Question 15. Do students have a way to track their own mastery of content in your class or do you do that for them?

Teacher 6: No, they do it on their own. They're getting back any assessments, they're meeting with me individually to look at our checklists, our assessments. They have access to their grades in real time. As soon as I assess something and I make comments on something, that's pushed to them right away. So they have the access to that as well as their parents or guardians, so they can see where they are. Nothing lives in secret. This is what we're doing, this is the purpose for it. This isn't just, I grade and then we move on. We're not living on work. Typically we're still going back to those concepts throughout the year.

Interviewer: Okay, great. Question 16. Are your students ever provided examples of quality work through exemplars? If so, what's their reaction to that?

Teacher 6: I do. I do use exemplars, whether it's something I've written myself or another student has written, not sharing who the student is. I think their knowledge is like I maybe can't do that and this is too much, or boy, how did they get that smart or that knowledge. So I do share pieces. If I'm looking at exemplars I'm probably showing in the nine weeks, probably four, maybe, tops. Especially when I'm not looking for something formatic, when I really want them to to show me what they know I think exemplars are great, but I don't want to stifle anyone's creativity or let anxiety or fear take over that their work because it doesn't look like example A is not valid or not appropriate or hasn't met the mark so we're just going to throw the towel in and say I can't do that or I'm going to let the procrastination monster take over here and block anything that I can give.

Interviewer: Right, right. Question 17. You already mentioned the one to one iPad and using technology quite often, so I think it's safe to say it's integrated in your lessons, but how do you choose when to use technology and has it ever negatively impacted your teaching?

Teacher 6: I don't have a real 100%, I know when I'm going to use it. I try to use it as much as possible because it offers me some true real-time feedback, especially if I'm doing something with like an informed assessment. It's great, especially for kids who struggle, like many kids struggle to keep all their stuff in one place. It's a great clearinghouse. So if we're taking notes, we're annotating, all this stuff is there. It lives in one place, it lives in one app, so it's all there. So for my friends who are prone to lose stuff, just like myself, it's a really nice way. Have I seen negatives? I think yeah, I see negatives. I think I can't remember a time 100% in recent years.

Teacher 6: I think sometimes when you're not real clear about what you want to teach or how you're going to get there and you're just using technology thinking that that's going to be razzle-dazzle to answer how do we engage the kids or what are they actually doing? And you don't know what they're doing or you don't know how they're going to get to or when your expectations really aren't finalized in your head.

Teacher 6: I'm still flexible with my expectations, but I think teachers, and I've shrugged at situations where I've just tried to use technology to be to the heavy hand, but it's not the heavy hand. Technology is like a calculator, really it's an asset that can be used next to you, but you are still in charge of the order of operations, if you will. You're still in charge of how does this go to connect to A, how does this connect to B, what's the purpose of this and what are you doing? Because if the lesson isn't clear then that's a lost class period.

Teacher 6: You always lose time in education, but you do it the wrong way and students aren't learning. We all make mistakes but you've got to make sure that you're very clear about why you're doing what you're doing.

Interviewer: Right. So I don't want to take words out of your mouth, but it sounds like what you're saying is kind of, first of all, technology can't really replace sound pedagogy and content knowledge, but there has a balance there, which is what most literature would say. How did you learn to do that? Were you trained to do that or did you just pick that up as you were going?

Teacher 6: No, I picked it up as I've gone. I've had the opportunity to do a lot of, in addition to the work that I do daily, I've had the opportunity to do Cyber School monitoring throughout my career, whether it be middle school and high school. So whether I'm the monitor of their work or I'm working with them as a supplementary source, which I've done more recently in my current district, so I'm like a supplementary education, if you will, a supplementary feature that content. There's a lot of things that are still lost. It's always interesting to me when I see students, I'm not saying cyber or education via technology is not great, but there's a lot of things that are still lost because there's not that ability to have a discussion.

Teacher 6: So I think it's along the way I've just kind of developed in my experiences and my toolbox to say, okay, cool, this works, but nuts and bolts. You can have the best lesson but your technology doesn't work or you're unclear about what you're doing or you can't control your students, their personal behavior or self-control is not there or technology needs to be unlimited, well, what are you actually teaching? Go back to the very bare bones of it and start there and then see how technology fits, and be very clear with yourself about where you're strong and where you're weak, because technology is one of those areas where your weaknesses or spots of confusion or lack of clarity can come out very quickly when technology is used inappropriately.

Interviewer: Okay, great. Yeah I think a lot of that goes back to when a lot of these technology things first came out, people thought they were getting kind of teach for them. I think we've progressed beyond that understanding of their goals, but speaking about students using technology, do your students use technology individually or in teams? Kind of thinking about that integration and how to use it. What does their use look like?

Teacher 6: Their use is going to be when they're individually working. And I think we're like many organizations, a Google product school, so Google Docs, Google Sheets, Google Forms, those pieces have been tremendously helpful, especially for real-time editing, for students working together collaboratively and I love it personally because I can sit down and we can edit, we can write together, and it's a very clear, hey we can knock this out together. It doesn't feel like the old school way of, just it didn't work fluidly.

Teacher 6: So each teacher is going to look a little bit different. To me we're more right now in the individual stages with some fluid, hey work together on this, you're going to be doing this assessment or this review as a team, and there's some great apps out there that I can throw my content in real quick for a quick review before we do an assessment. So they're working collaboratively to review and talk about the content and review the content before we do an assessment, which has been very, very helpful for my students.

Interviewer: Okay, great. And my last question is just clarification. So you guys are one to one for iPad, but you use mostly Google products?

Teacher 6: Um-hmm (affirmative).

Interviewer: Okay. Well, thank you so much.