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A Study of the Teaching Beliefs of the Modern Post Secondary Science Instructor and Implications They May Hold for the Future of Science Education

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The University of Southern Mississippi

A STUDY OF THE TEACHING BELIEFS OF THE MODERN POST SECONDARY SCIENCE INSTRUCTOR AND IMPLICATIONS THEY MAY HOLD FOR THE FUTURE OF SCIENCE EDUCATION

by

Michael Charles Howard

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
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ABSTRACT

A STUDY OF THE TEACHING BELIEFS OF THE MODERN POST SECONDARY SCIENCE INSTRUCTOR AND IMPLICATIONS THEY MAY HOLD FOR THE FUTURE OF SCIENCE EDUCATION

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It was the purpose of this study to examine the teaching beliefs of community college science instructors and discover whether their teaching beliefs were student oriented or instructor oriented. In addition, this study sought to examine demographic factors and find their relation, if any, to these teaching beliefs, as well as explore topics that may be useful in the future to helping community colleges science instructors' curricula and beliefs come together and work in unison. To do this, the study built on the foundation laid by Sampson et al., in their creation of the Beliefs about Reformed Science Teaching and Learning (BARSTL) questionnaire. This study consisted of the BARSTL framework, together with six demographic questions and four short answer questions. Quantitative and qualitative methods were used to analyze the significance of the differences between the BARSTL score and the demographic groups created by the questions.

Mean BARSTL scores and subscores for all 36 demographic groups created by the demographic and short answer questions were calculated. Homogeneity of variance between the groups created by the nine questions was calculated where the group size was sufficient to meet statistical requirements (one question had a single, overwhelming, common response). Eight ANOVAs were then used, along with post hoc tests where

appropriate, to see if there was a significant difference between the BARSTL scores in the groups created by eight questions. Additionally, eight MANOVAs were used, along with post hoc tests where appropriate, to examine whether there was a significant difference between the BARSTL subscores in the groups created by eight questions. Further, one question lent itself to a t-test to examine the difference in the groups created by the two most common responses, and it was performed as well. Certain responses to the four short answer questions were also explored using qualitative means to further understand why community college science instructors responded in the manner in which they did and what implications their responses may have for community colleges and science beliefs.

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DEDICATION

The writer would like to dedicate this dissertation to Elizabeth Howard, his mother, without whom he would have never entered the teaching profession. Without her guidance and support, none of this would have been possible.

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TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF ILLUSTRATIONS

Figure

CHAPTER I

INTRODUCTION

Overview of Teaching Beliefs

Teaching beliefs are the thoughts and feelings held by teachers about their position and their role in the teaching environment (Cross, 2009). For example, a teacher may believe that students learn best by working together, and that it is the role of the teacher to spur creative interaction between students. Other teachers may believe that memorization of important concepts is key, so they might use drills and other methods to ensure that students leave the classroom with certain important facts instilled within them. Still other teachers might believe that a standard lecture setting is the best method of instruction and plan their classroom around that idea instead. All of these are teaching beliefs--founded in teaching methods and other principles instilled in teacher training, but now part of the internal belief structure of the teachers. These teaching beliefs, once instilled, are very difficult to change.

Teaching beliefs serve as a lens through which teachers interpret new ideas and teaching methods (Sampson, Grooms, & Enderle, 2013). Teaching beliefs not only shape how a teacher perceives new ideas, but also how they implement them. Research has shown that if a teacher's beliefs are not compatible with the philosophy of the curriculum, it will not be successfully implemented in the classroom (Cronin-Jones, 1991). Clearly this is true. If teachers are asked to implement an idea in the classroom which they either do not believe to be correct or do not fully understand, of course they will not succeed. Please note that this study is not considering active opposition by a teacher to a curriculum--what is being discussed is a natural, internal resistance to ideas in opposition to teachers' own beliefs. For example, suppose teachers believe that a lecture setting is the best method of instruction. Teachers are then asked to use a group focused method instead. In spite of their best efforts, these teachers will have difficulties in implementing the new method, simply because it conflicts with their core belief systems.

Research has also shown that teaching beliefs are resistant to change, even when they are the focus of a significant effort to do so (Yerrick, Parke, & Nugent, 1997). In *Struggling to Promote Deeply Rooted Change,* Yerrick et al. developed and ran a two week summer institute designed to change what science instructors believed about the nature of scientific content in their courses and the role that students play in the classroom. Despite active and enthusiastic involvement by teachers at the institute, the researchers found through interviews that the fundamental belief system of the teachers did not significantly change. The new information given to the teachers at the institute was simply added to what they already knew and interpreted in such a way that it meshed with the belief structure that was already in place. Clearly, trying to address this issue by altering teaching beliefs may be a very difficult proposition.

Though much has been written about teaching beliefs, it is only recently that detailed quantitative tests have been developed to accurately measure them (Sampson et al., 2013). Sampson et al. developed the BARSTL to examine how receptive a particular teacher might be to a modern constructive classroom. The BARSTL itself does more than this, though--it accurately measures the teaching beliefs of a given instructor in four key areas: how people learn about science, lesson design and implementation, characteristics of teachers and the learning environment, and the nature of the science curriculum (Sampson et al., 2013). It is the goal of this dissertation to implement the BARSTL developed by Sampson et al. and investigate the teaching beliefs of community college science instructors in the Southeastern United States.

Community College Demographics

In the United States there are currently 1,721 two year degree granting post-secondary institutions (which will be referred to as community colleges) and 2,774 four year degree granting institutions (NCES, 2012). As of fall 2009, these community colleges had a total enrollment of a staggering 7.6 million students and graduated 599 thousand with associates' degrees (NCES, 2012). Compare this to four year institutions, which had an enrollment of 12.9 million and graduated 852 thousand students with at least a bachelor's degree (NCES, 2012). Community college students are a unique demographic. Like four year students, they are majority female (57%). However, 56% of the community college students are part-time, as compared to only 27% of students at four year institutions (NCES, 2012). The average age of enrolled students is similar, with 44% of community college students being 21 years or younger and 43% of four year students the same. (NCES, 2012). Contrary to popular opinion, the percentage of students enrolled in remedial courses is similar at two and four year schools, with numbers at community colleges typically 1-2% higher than a four year institution. For example 18.3% of first year undergraduates at community colleges took remedial courses, as compared to 16.3% of first year undergraduates at four year institutions (NCES, 2012). This means that community college academic students are enrolled in similar classes to their four year counterparts, and that their instructional needs are quite similar. However, community college students are mostly part-time.

When examining the faculty of community colleges, some interesting numbers arise. Fifty-eight point five percent of the total faculty and staff employed at community colleges around the United States are instructors. Compare this to only 29.9% of the total faculty and staff at a four year institution having teaching duties (NCES, 2012). Community colleges also, as a rule, do not employ graduate assistants, meaning that every course at a community college is taught by a paid instructor, which is quite different from a four year institution (NCES, 2012). In addition, every instructor at a community college must have at a minimum a masters' degree and 18 hours in their chosen field. Community college instructional faculty are also majority female (53.6%), which is not the case in four year institutions (only 44% female). Race/ethnicity distribution among faculty of two and four year institutions is quite similar. For example 10.2% of community college faculty register as African American people, and 9% of four year faculty register as the same. There however is a far larger representation of Asian American people among four year institutions (6%) as compared to two year institutions (3%) (NCES, 2012). In addition, the majority of instructional faculty at a community college level (69.8%) is part-time, which is quite different from the situation at a four year institution, where only 32.2% of faculty are part time (NCES, 2012). Even part-time faculty at a community college must meet the same requirements as full-time faculty; they must hold a masters' degree and have 18 hours in their chosen field. Note that this matches the student population of community colleges as well; both community college faculty and students are majority part time. They both balance outside needs with the classroom.

Perhaps the largest difference in the faculty of two and four year institutions is where they spend the majority of their time while at work. Community college faculty spend 78.4% of their time teaching or in teaching related activities, where faculty at four year institutions spend between 43.5% of their time (at a research institution) and 64.7% of their time teaching (at a non-research institution) (NCES, 2012). Perhaps the largest difference between community college faculty and four year faculty comes from their contact with students. Fifty-eight point two percent of community college faculty actively teach 15 or more hours a week. Four year faculty do not come close to this workload, with only 5% (research) to 15% (non-research) of their faculty actively teaching 15 or more hours a week (NCES 2012). This translates into 41% of community college faculty actually teaching 15 or more credit hours (47.6% teach at least five classes--the difference lies with labs for science instructors). Four year workloads do not come anywhere close to this, with only 4% (research) to 12% (liberal arts) of faculty teaching 15 or more credit hours a week (NCES, 2012).

So, what does all of this mean? First, note that the academic needs of community college students are the same as their four year counterparts. In addition, a majority of community college students are part time means that they are balancing other concerns with the classroom. Community college instructors themselves typically are in a similar situation, with a majority of them also working part-time. However, when community college instructors are on campus working, they are actively engaging with the students at a very high rate, coming into contact with and teaching students at a higher rate than any other post-secondary institution. All of these factors go into shaping the teaching beliefs of a community college instructor, and this study will show how these interesting demographic facts impact community college instructor teaching beliefs.

Statement of the Problem and Justification for Study

Every year, new and exciting textbooks and curricula are developed for college classrooms. Every year, colleges spend much time and money adopting these new ideas. And yet, in many cases, the actual classroom environment changes very little. It is not that instructors are "hostile" or actively opposed to new ideas, but that the curricula itself conflicts with their internal teaching beliefs. Current research shows that if a curricula conflicts with a teacher's beliefs, it will be quite difficult for the teacher to implement those ideas in the classroom (Feldman, 2002). Furthermore, teachers' beliefs are not fungible; they cannot be changed with a mere workshop or 12 hour course (Yerrick et al., 1997).

Therefore, if the teachers' beliefs are not going to change, the curriculum must. Curricula must be adopted by institutions of higher learning which take into account the teaching beliefs of their faculty. This will enable both the curriculum and the faculty to function in an efficient manner. Unfortunately, it is quite difficult to measure teaching beliefs. What instructors claim to believe and what they actually believe may be quite different, and clearly an institution should not adopt a curriculum based on what instructors think they themselves believe without empirical evidence (in many cases, this is what is unintentionally being done now).

This leads to the goal of this dissertation. Here, this study will use cutting edge research to analyze the teaching beliefs of community college science instructors in the

Southeastern United States. Not only will the study produce a snapshot of how the average instructor thinks, but it will take a step further and see if these teaching beliefs are correlated with any of a variety of factors--including years teaching, discipline taught, and so forth. Hopefully, this dissertation will enable community college administrators and community college faculty to better understand themselves and work towards the adoption of practical curricula.

Research Questions

Descriptive analysis will be used to address the following research questions:

- Where does the average community college science instructor in the Southeastern United States lie on the BARSTL continuum? Do they have a traditional discipline-focused approach, or do they have a constructivist student-centered approach?
- Where is the average instructor placed in the individual BARSTL categories: how people learn about science, lesson design and implementation, characteristics of teachers and the environment, and the nature of the science curriculum?

Statistical analysis will be used to address the following research questions:

- Is there a significant relationship between teaching philosophy (BARSTL score) and years of teaching experience? Is there a significant difference between BARSTL components and years of teaching experience?
- Is there a significant relationship between teaching philosophy (BARSTL score) and gender? Is there a significant difference between BARSTL components and gender?

- Is there a significant relationship between teaching philosophy (BARSTL score) and the specific science which is primarily taught by an instructor? Is there a significant difference between BARSTL components and the specific science which is primarily taught by an instructor?
- Is there a significant relationship between teaching philosophy (BARSTL score) and whether or not an instructor is full or part-time? Is there a significant difference between BARSTL components and whether or not an instructor is full or part-time?

Qualitative analysis will be used to address the following research question:

- What do community college science instructors believe "drives" their discipline? What causes it to change and evolve? Is it driven by discovery? Is it driven by outside forces?

Definition of Terms

In this paper, community college means a two year private or public degree granting institution which is a Title IV program, capable of receiving financial aid from the federal government. For profit schools will not be considered as community colleges for purposes of this study.

In this paper, science instructor means an instructor whose duties consist primarily of teaching mathematics, computer science, physics/physical sciences, chemistry, or biological sciences. It is common in community colleges for one instructor to teach multiple disciplines, but typically science instructors teach mostly science courses (for example, a mathematics instructor may teach computer science, or vice versa).

How people learn about science, as a BARSTL category, describes how instructors believe their students best learn about science. This includes opinions on natural ability in science, as well as beliefs about overall structure of the classroom setting, such as whether or not open and lively discussion is encouraged in the classroom.

Lesson design and implementation, as a BARSTL category, describes how an instructor best believes a science lesson should be designed and taught in school. This includes opinions on experiments and inquiry focused techniques in the classroom.

Characteristics of teachers and the learning environment, as a BARSTL category, describe how an instructor believes the best teachers should act and how their classroom should be run. This category focuses on the students' role in the classroom, and exactly what role they should play in the learning process. Another part of this category is whether the instructor believes individual or group focused assignments are best for instructing students.

The nature of the science curriculum, as a BARSTL category, describes how an instructor believes the optimal science curriculum should be designed. Should a curriculum be broadly designed, but shallow in that it only covers a few important topics from each section? Or should it be narrowly focused but deep, so that students will master a few key ideas instead?

Delimitations

This study will focus on community college science instructors in the Southeastern United States.

Limitations and Discussion

The first limitation to this study is the population sample. Responses will only be drawn from community college instructors in the Southeastern United States. The results of this study may not be able to be generalized outside of this specific population. In addition, the topic of this survey may be considered by some instructors to be sensitive, especially if they are currently involved in a disagreement with other members of their department in how to teach a topic. This may lead some respondents to respond with what they feel is an "ideal" answer rather than their personal beliefs.

Assumptions

- This paper will assume that instructors will answer the questions based upon what they believe is proper in the classroom, rather than what they think the study wants to hear.
- This paper will assume that all instructors understand English sufficiently to be able to read and respond to the questions in a cogent manner.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction to the Concept of Teaching Beliefs

Teaching beliefs are quite different from teaching knowledge, though they can be seen to be related to the standard schools of teaching knowledge. Research has shown that only between three and five constructs are used in the creation of teaching beliefs in a particular teacher (Yerrick et al., 1997). Generally speaking, these constructs are taken to be student learning, student involvement, teacher control, student needs, and motivation. Belief systems are emotional--how does a teacher feel about a particular aspect or style of teaching? (Nespor, 1987). These emotions can be seen as separate from the actual knowledge structure. For example, a player may know the rules of soccer but not like them, or think that a particular rule is necessary (Yerrick et al., 1997). However, it would be a mistake to wholly separate teaching beliefs from teaching knowledge. Teaching beliefs may perhaps best be viewed as a window through which one can interpret teaching knowledge.

The principal role of teaching beliefs is to allow a teacher to deal with complicated situations. Classically, these situations are called “ill-structured problems” and “entangled domains.” An ill-structured problem is one which requires the reader to go beyond the given information--possibly including problems which have no real solution at all (Nespor, 1987). An entangled domain is a situation where more than one set of learned rules may apply, and it is up to the instructor to decide how to act (Nespor, 1987). With a little thought, one can see that these situations happen in the classroom every day. The very classroom setting is an entangled domain, where knowledge of classroom management conflicts with knowledge on instruction, as well as knowledge of time management. Every day, instructors are requred to enter this environment and make decisions. These decisions are based primarily on the teaching beliefs of the classroom teachers (Yerrick et al., 1997).

These aspects of teaching beliefs also directly impact larger goals within certain approaches to teaching. For example, if teachers value order and control in the classroom, they will have rules and other systems in place to enforce discipline and control. It has been found that teachers who emphasize order de-emphasize group work and may not believe that it has an important role in the classroom (Cronin-Jones, 1991). The relationship here is obvious--group work at any level tends to be noisy, and at the very least introduces disorder into the classroom. It is quite obvious that a teacher who prioritizes order would not be happy at introducing disorder into her classroom. It is also quite clear that a teacher who prioritizes student involvement in the classroom would be more than willing to tolerate the disorder of groups if it furthered her goal of student participation in the learning process.

Three Traditional Schools of Teaching Knowledge

Traditionally, educators and historians of education have viewed teaching knowledge as falling into three schools of thought. Classifying writings and thoughts of new thinkers into one of these three schools enabled the average teacher to see quite clearly the beliefs of the cutting edge, and competition between these schools allowed for growth in the field of education. This view worked for quite a long time in education. It is worth briefly exploring these three schools of thought, so that one may better understand how the continuum approach to teaching beliefs fits into this groundwork.

Cognitive

The cognitive school of thought has only come to the forefront of education in the 1960s. However, in many ways, the cognitive school is the most dominant in modern education. A cognitivist examines education and learning in a scientific way to find the best manner in which a child will learn. These ideas are taken directly from learning psychology and applied directly to the classroom. Cognitive learning theory was first proposed by Jean Piaget in 1926 in his work *The Language and Thought of the Child.* Though it took the intellectual world by great surprise, only much later were the ideas first proposed by Piaget refined and brought into a formal school of thought. Jerome Bruner in his work *A Study of Thinking* published in 1956 truly coalesced Piaget's ideas into a rigorous form that can be called a the cognitive school of teaching. With Bruner's work, the cognitivists slowly began to rise to prominence throughout education, becoming dominant by the 1960s and beyond.

Their study of the human brain tells cognitivists that to successfully learn a concept, students must first pay attention to a concept and transfer it to short term memory. Then, a learner connects this concept to ideas already in long term storage. If the connection is successful, the idea is transferred to long term memory. If not, it is forgotten. There are many different ways to do this, but a popular method of teaching from the cognitivist school is using real world problems in the classroom, sometimes even going as far as to use directed learning, where the students themselves are asked to discover new ideas (Cruickshank, Metcalf, & Jenkins, 2009). In this way, cognitivists promote not only the learning of new ideas, but their application in everyday life.

Humanistic

The humanist school of thought was possibly the first dominant school of educational thought. Humanism can be tied to social psychology and focuses on the social and emotional growth of students. To a humanist, the role of a school is to make a child happy and able to learn (Cruickshank et. al., 2009). Learning is important, but secondary.

Humanism was one of the primary factors behind the growth of public schools in the United States. Indeed, Charles Eliot, chair of the 1892 Committee of Ten which marks the beginning of the standardization of public schools, was a staunch humanist (Kliebard, 2004). Humanism in the nineteenth-century took the view that all students should be educated as if they are going to college. This meant that college curricula and high school curricula were aligned for the first time. Incidentally, this meant that, since some colleges were including sciences on college entrance exams, the sciences began entering high schools broadly. Note that this is an important change--that all students are to be treated equally. One can see the traces of modern humanist thought in Eliot's initial concepts. Over time, humanism evolved through the Progressive movement in the 1910s and 1920s and began to incorporate emotional and social norms as well, culminating in the idea of social meliorism in the 1930s, which held that the primary function of a school was to push social change rather than to teach a child to conform to society (Kliebard, 2004).

The core ideas of modern humanism can be traced back to the psychologist Maslow, who wrote in 1954 about the hierarchy of needs. Essentially, Maslow believed that basic needs, such as survival, happiness, and self-esteem, must be satisfied before a student can progress to higher needs, such as learning in a classroom (Maslow, 1954). This focus on the wellbeing of the child resonated strongly with humanists and transformed modern humanist thought.

Behavioral

The final school of thought lies in the behaviorists. Behaviorism has its roots in behavioral psychology. Behaviorists believe that learning is driven primarily by the environment of the learner. By shaping the physical and social environment of the learner, a teacher can drive them toward the proper outcome (Cruickshank et al., 2009). John B. Watson is seen as the father of modern behavioral psychology, and his work *Behaviorism* published in 1930 marked the formal creation of this school of thought. Watson was a child psychologist, and it is no surprise then that he focused much of his work on the growth of children. Watson believed strongly that the growth and maturity of a child was entirely based upon his environment. Therefore, if an instructor changes the environment to be one promoting learning, then learning would naturally follow suit. Behaviorism as a school of psychology has fallen from the prominent level it once had in the 1950s and 1960s. However, the methods used within behaviorism are still quite effective, and so it maintains influence to this day.

In education, a behaviorist focuses on direct instruction--where a teacher outlines step by step what a student should do to succeed. When a student succeeds, they are praised; when they fail, the student is given a chance to succeed again. Through positive reinforcement, learning takes place (Cruickshank et al., 2009). Many modern teaching methods using technology also incorporate similar methods to teach the student. Because of the wide applicability of behaviorist ideas, educators still use and support this school of thought, and it has a strong adherence today.

Interpreting Teaching Knowledge as a Continuum of Teaching Beliefs

Rather than look at teaching beliefs as schools of thought (similar to teaching knowledge), recently some researchers have reexamined teaching beliefs as all being aspects of one central continuum. This is especially important in science education, where the tensions between a duty to the purity of science and a duty to the student are quite strong (Sampson et al., 2013). On one end of the continuum one has a traditional classroom setting, focusing on direct instruction using the behaviorist model. Rigid control is exercised in the classroom, and order is a priority. Science is rigorously taught, with a focus on creating new scientists. As one topic is finished, the next is introduced. On the other end of the continuum there is a free-form constructivist classroom, with a focus entirely on the student. Independent study and guided learning using both cognitivist and humanist beliefs are applied to make lessons which not only make a child happy but are easy to learn. However, classroom order is not a priority, and the classroom has the potential to become quite chaotic and disorderly. It is important to note that both methods work--clearly directed learning worked for generations of American students.

So far, the continuum does not appear to be any different than what has been discussed previously. However, note that continuum implies that people lie between these two extremes. There may be instructors who always use directed instruction, and there may be instructors who always use constructivist practices. However, the vast majority of teachers will incorporate elements of both into their teaching. If you asked the average teacher "Why do you teach in this way?," they would respond "because it works" or "because it feels right" (Cross, 2009). It is this emotional idea that this study wants to measure--what an instructor "feels" to be right. In this way, this study can then reexamine the course of science education in light of this idea. At some points, the majority of science educators were on one end of the spectrum, and as time goes on they shift, and then shift back. Measuring where teachers lie on this spectrum is the goal of this study.

A Reexamination of Science Education in Light of the Continuum Approach

"Objectivity" and Early Science Education in America

In the early 1800s, science education was split into two completely different areas. Mathematics had long been taught in colleges and preparatory schools, and was seen as essential for the working of a sound mind. The content of the mathematics was not as important as the discipline instilled by working mathematical problems. Biology, physics, and chemistry, being quite new disciplines, were not given much respect by formal colleges and preparatory schools. Instead, these disciplines were principally taught in girls' schools and used as "finishing subjects" to educate well-rounded young women (Tolley, 2003). The sciences were taught through stories and other parables designed specifically for these schools to reach young girls and women (Watts, 2007). Science taught in this format was very applied and focused on experiential methods—i.e., a class would explore the nature of a flower which it saw outside or study a bird upon which it happened. Even the textbooks engaged in a dialogue with students, relating scientific ideas to practical experiences in everyday life (Tolley, 2003). This dialogue was written as a conversation between women, which helped to ensure that young girls embraced scientific topics (Watts, 2007).

However, this does not mean that these lessons were cursory or not scientifically sound. An examination of textbooks from this time shows that they were quite detailed, including sample chemistry experiments using easily available substances (Watts, 2007). The goal of this science education was quite straightforward—it was believed that a woman well educated in the sciences would be a well-rounded individual who could find practical uses for scientific know-how (Tolley, 2003; Watts, 2007). These everyday uses of science were important to the successful running of a household and raising of children—everything from the manufacture of soap to dealing with dyes and instructing children on the species and nature of various plants and animals. In her career as a homemaker and manager of a farm or business, a woman was expected to know many of these scientific concepts; indeed, most women knew more of them than their husbands (Tolley, 2003).

As more and more scientific discoveries were made in the late 1800s science began to gain national prominence. The publication and acceptance of scientific works such as Darwin's *Origin of the Species* among the lay public began to slowly transform academia and encourage the inclusion of a variety of scientific disciplines (Angulo, 2012). As college entrance requirements began to include chemistry and biology over traditional subjects such as Greek and Latin, lower schools began to follow suit. As science education was instituted in the traditional (male) college preparatory schools, it was slowly eliminated from the (female) finishing schools. Part of this shift was a quick and brutal denigration of women who practiced science. Scientists such as paleontologist

Marry Anning and mathematician Mary Somerville were barred entry into the Royal Society in Great Britain (Watts, 2007). Their complaints were met with comments implying that their work was not real science, in spite of the fact that Marry Anning's bust was in the great hall of the Royal Society to honor her contributions to her field (Watts, 2007). Science education had become part of the traditionally male system of formal higher education, joining mathematics, which unfortunately had the result of shutting out future female scientists (Watts, 2007). Also at this time, the sciences themselves became more and more enmeshed with mathematical concepts and theory, which served to further intertwine the two (Angulo, 2012).

Mathematics had been long embraced by both male and female schools as not only necessary to functioning in society (practicality), but as a source of "mental discipline" and structure for new students (CSMSG, 1961; Jones, 1967; Watts, 2007). Early mathematics education stressed memorization and structure, so, standard mathematics texts of the time were written in a similar manner. Each textbook typically gave rules, then worked examples, and finally gave practice problems of increasing difficulty (CSMSG, 1961; Jones, 1967). This very structured, ordered version of mathematics was to serve as a model for the inclusion of the sciences in schools.

The science which was included in the traditionally male preparatory schools was not the same science which had been part of the finishing schools. The reason for this was simple—science education now had a different focus and a different purpose. Rather than a goal of giving young women a general useful scientific background, science education was now changing to prepare primarily male students for entry into college. The science taught in college was designed to test the mind and exercise thinking skills, rather than create a new generation of scientists (Watts, 2007). This new science education began to emphasize facts and replication of existing experiments and de-emphasize general scientific understanding (the forerunner of scientific literacy) and an application of science to the real world (Watts, 2007).

This was a radical shift in science education. Slowly, study of these new sciences, along with a new emphasis on mathematics, began to replace an emphasis on study of the classics (chiefly Greek and Latin) in preparatory schools and colleges (Angulo, 2012; CSMSG, 1961; Roberts, 2001; Watts, 2007). These institutions of learning used the same methods which had been successful in previously teaching mathematics and applied them to the newly included sciences. The same rigorous precision which was successfully used in teaching the classics was now applied to science education. Individual scientific subjects needed to be broken down into testable components (Roberts, 2001; Watts, 2007). Students themselves were expected to memorize and repeat back scientific ideas and principles.

Science education itself evolved from this end point--a goal of producing students who were capable of reciting formulae and replicating basic proofs and experimental components. Rather than being taught interesting stories and applied scientific ideas, students were drilled on how to replicate proofs and memorize basic concepts (CSMSG, 1961; DeBoer, 1991). Memorization and an emphasis on precision which would seem almost absurd today was key in these first science classes (DeBoer, 1991). Many educators encouraged the study of science not for the sake of learning scientific theory or method but instead to encourage mental toughness and rigor—the very same reasons cited for the study of mathematics decades before (CSMSG, 1961; DeBoer, 1991;

Roberts, 2001). These educators viewed sciences as being superior to classical languages for study because of the difficulty of the sciences and their inclusion of a wide variety of mental disciplines (CSMSG, 1961; DeBoer, 1991). However, these early science educators did not believe that it was their role to promote investigation or even scientific thought. Indeed, the first college entrance exams which included science were replications of a series of basic experiments in scientific disciplines, yet even the inclusion of these basic experiments was a remarkable step forward for science education at the end of this era (CSMSG, 1961).

Thus, science education entered into a pseudo-objectivist era. Just as historians and other disciplines emphasized facts, figures, and accuracy, science educators emphasized knowledge and repetition of ideas (CSMSG, 1961). Both disciplines had adopted a profoundly objectivist viewpoint, with clear notions of what was required and what was important. The philosophical changes that were to come as the twentieth-century approached would profoundly change both disciplines in remarkably similar ways.

The Progressive Movement and its Impact on Science Education

Not all disciplines had such a strong and negative reaction to relativism and related schools of thought. Science education benefited greatly from the changes and new perspectives brought by the Progressive Movement (Fiss, 2012). This change in thought became dominant in science education much earlier than in American history—for a variety of reasons (CSMSG, 1961; Fiss, 2012).

First and foremost of these reasons is that science education itself was quite new. In fact, the progressive school ultimately served to spur the creation of science education as a discipline. As a new area of study, science education was much more susceptible to new and different types of thinking (CSMSG, 1961). Compare this to history, which has been studied and taught for literally thousands of years in classrooms around the world. Second, population growth had spurred the institution of compulsory education around the United States. This spawned the creation of high schools, which took the place of the preparatory and finishing schools of the past. High schools took on not only the mission of educating students for college, but also educating them for functioning in the real world (CSMSG, 1961; Fiss, 2012). Science education was a part of this, and science educators entered the field by the thousands. These new science educators had their own desires and needs, and they were quick to embrace new ideas.

Relativism, or progressivism, in education strives to bring the ideas taught in the classroom closer to the real world. This has two different successive strands in science education. First is the idea that science must be taught through laboratory experiments and fieldwork, since that is how science is created and nurtured in the "real world" (CSMSG, 1961; Roberts, 2001). Progressive science educators believed there was a limit to the amount of knowledge which can be gained from simply reading and memorizing a textbook.

Part of this thinking was a reaction to the bloated science curricula that had been created in the early days of science education. There was a great deal of information in science, and the new science curricula strived to include almost all of it. A great deal of this was simply memorization for the sake of memorization—to strengthen the mind. Without a uniform standard stating what new students needed to know, high schools felt forced to teach a broad spectrum of ideas (Fiss, 2012). This broad based education was by necessity quite shallow, and ultimately rising numbers of student failures in mathematics and the sciences in general became a national concern (CSMSG, 1961). In response to these and other concerns, scholars (including scientists and mathematicians) and educators from around the country came together in 1894 to create a uniform standard of college entrance requirements. This gathering became known as the Committee of Ten, and its science and mathematics sections helped to fully bring the sciences into the classroom (CMSG, 1961; Fiss, 2012). They also served to combine Progressive ideas with the old science curriculum, and indeed many of the science educators who were part of the Committee of Ten thought of themselves as Progressives.

The Committee of Ten made recommendations in a variety of educational areas relating to science, but some overall recommendations were quite clear. First, the Committee of Ten advised that one fifth of high school instructional time be devoted to science, and that all science classes should be taught with a laboratory section. It went further to recommend that natural science classes have at least one day a week where they observed nature outside, in its proper setting (DeBoer, 1991; Fiss, 2012). Even in mathematics, mathematicians such as E.H. Moore pushed for what they called a "laboratory method," where problems in practical mathematics were used to introduce higher mathematical concepts (Fiss, 2012; Roberts, 2001).

The Committee findings were a clear and sharp break with the objectivist teaching methods of the past, and they were a clear indicator that a new change had overtaken science education. A Progressive push for inquiry and laboratory teaching of science had clearly come into the forefront (Fiss, 2012). In the wake of the Committee of Ten, laboratory science did indeed become a standard part of the college entrance exams, and in turn, certain sciences became a standard part of high school curricula (DeBoer, 1991; Fiss, 2012).

However, to some Progressives, this emphasis on laboratory science came at a cost. Soon after the full inclusion of science education in the general high school curriculum (and the rise of high schools themselves), science educators began to realize that many, perhaps most, of the students in science courses would not continue in scientific fields (Fiss, 2012). In addition, many scientists and mathematicians themselves began to be increasingly reluctant to involve themselves in education (Roberts, 2001). Many scientists viewed themselves as being above the field of education, and, moreover simply did not feel that education was a worthy pursuit for them (Roberts, 2001). Science educators were left to find their own way, and they began to find more of a connection with the students themselves.

These new science educators determined that the goal of science education then should not be educating future scientists, but in giving students a well-rounded background which could help them in their future life (Note that this is well before the modern idea of "science literacy."). Science education was seen to go hand in hand with vocational education (electronics and mechanics) along with health and hygiene (biology). Science educators therefore believed that they should work to strengthen and highlight these connections rather than focus on specific scientific principles (CMSG, 1961). In 1913, the National Education Association Department of Secondary Education established the Commission on the Reorganization of Education (DeBoer, 1991). This commission was created to "modernize" high school curricula and bring them in line with current educational thought. The Science Committee of the Commission on the

Reorganization of Education worked to bring these new Progressive ideas into science classrooms (DeBoer, 1991).

In 1920, the Commission report was released. Deboer wrote in 1991 that the Commission Report listed seven core values to be emphasized in high school curricula: "(1) health, (2) command of fundamental processes, (3) worthy home-membership, (4) vocation, (5) citizenship, (6) worthy use of leisure, and (7) ethical character" (p. 68). Academic training, which had been at the core of high school education, had been reduced to a mere component of value (2). This meant that all high school courses needed to be completely redesigned, especially science and mathematics.

The Science Committee focused on redesigning science curricula to address these new values. They argued forcefully that the goal of teaching science was to create a happy and productive member of society (DeBoer, 1991). To this end, science courses were redesigned to focus on applications of scientific principles rather than on the science itself (DeBoer, 1991; Stanic, 1986). To this end, topics such as hygiene, vocational preparation, and the scientific method became part of the new science curriculum. The ideas of the reformers also had another, quite different, effect on science education. The Progressives worked to redesign the entire science curriculum so that "students could comprehend it in relation to their own experiences" rather than from the perspective of the scientist (DeBoer, 1991; Stanic, 1986). Part of this redesign was a de-emphasis on the laboratory setting. Mindless, repetitive laboratory tasks were not seen as developing any worthwhile knowledge in students (DeBoer, 1991). Moreover, Progressive reformers believed that the only truly worthwhile laboratory for the sciences was the field. For example, they thought that biology students should go outside and view nature as nature (DeBoer, 1991).

Though it took a few years, the 1920 report of the Commission on the Reorganization of Higher Education profoundly affected the course of secondary education in the United States. Within the next decade, many if not most of the core ideas of these Progressive reformers were instituted into classrooms across America (DeBoer, 1991; Stanic, 1986). Though the old Progressives were able to have a few successes (namely the standardizing of science curricula and the institution of standardized tests), these new Progressives were clearly dominant in science education by the 1930s and through the 1940s.

As these newer Progressives gained clear dominance in all forms of education, they began to eliminate all traces of the older Progressivism in schools. Progressives and the Progressive movement in education successfully pushed schools in the 1920s and the 1930s to make themselves "socially efficient" (Roberts, 2001). Classes were divided between the academic and the practical, and academic programs were ruthlessly slashed (Roberts, 2001; Stanic, 1986). Programs such as mathematics which were not seen to be socially relevant were limited or eliminated entirely by the 1940s (Stanic, 1986). This would ultimately have dire consequences for the actual formal education of students, as Americans would discover after World War II.

Both of the schools of thought described here can be traced directly back to the Progressive Movement in science education (Jones, 1967). Even though they seem diametrically opposed today, it is enlightening to see that they both arose from a push to bring the classroom together with the real world. These two schools simply have differing ideas on what constitutes the "real world." Is the real world made up of scientists out in the field, or is it made up of the average man or woman in everyday life? The answer to this question clearly drives the two competing schools of thought in the Progressive Movement from this time.

The Post War Period and the Modern Era of Science Education

World War II taught science educators quite a different lesson from historians. Science educators too were caught up in the great post war fervor of patriotism which swept through the nation, but they also had become aware of a serious issue. For many different reasons, the actual scientific and mathematical knowledge of all Americans, but especially servicemen, was clearly shown to be lacking in World War II (Wissehr, Barrow, & Concannon, 2011). Simple mathematics necessary to calculate supply distribution were a challenge, and the trigonometry necessary for ballistics or flight calculations were simply not possible for the general population of servicemen (Kerr & Lester, 1982). Basic knowledge of science and especially mathematics of the general population of America was shown to be sorely lacking in all major areas by World War II. These young men and women were not all poor students. Indeed, some had been quite successful in the classes which they had taken.

The problem lay in the classes themselves. New Progressives had ultimately created classes that were highly relevant to the average student but which stripped out a good deal of raw math and science content. Indeed, even as early as the 1920s, states had begun to eliminate mathematics requirements in high school (Stanic, 1986). By 1934, only 30% of American public high school students were enrolled in Algebra courses during their four years of school, and only 17% were enrolled in geometry courses

(Stanic, 1986). Mathematics teachers themselves had warned as early as the 1920s and 1930s that the marginalization of mathematics in public school curricula was dangerous, but it was not until after World War II validated their fears that their concerns were addressed (Stanic, 1986).

The miserable mathematics and science knowledge of servicemen in World War II forcefully demonstrated to science and mathematics educators that their methods had failed. They realized that changes must be made in America's educational system for the United States to be competitive. Contrary to their historian brethren, their response was to reject most of the late Progressive ideas of the 20s and 30s, and return to a much more traditional early Progressive curriculum (Kerr & Lester, 1982). "Mathematics for victory" was the order of the day--mathematics, and indeed all of the sciences, were necessary for success in the Cold War (Fiss, 2011). The Cold War, and especially Sputnik, spurred even more of an embrace of traditional ideas and a very pure, focused form of science education. These traditional curricula, adopted in the early 1950s throughout the sciences, were quite effective in teaching concepts from mathematics and science, and even today are referenced in a wide variety of texts (Wissehr et al., 2011).

Science education continued to emphasize content through the 1950s and early 1960s. By the (late) 1960s, science and mathematics educators were working to incorporate even more science into their curricula by incorporating the assistance of scientists and mathematicians (BSCS biology and other similar science programs; the "New Math") (Tisher, Power, & Endean, 1972). These programs marked a full embrace of early Progressive ideals, trying to bring the ideas and methods of the laboratory into the classroom. Biology curricula were designed to create new biologists, and mathematics curricula were designed not only to teach arithmetic, but also to teach the underlying structure of mathematics, which was a wholly new idea.

Some of these Progressive reformations of curricula were quite successful. The BSCS curricula for biology were adopted by 43% of surveyed school systems by the 1976-1977 school year (DeBoer, 1991). The chemistry and physics curricula were far less successful, with less than 20% of schools using reform curricula in either subject. (DeBoer, 1991). The New Math program was so theoretical as to be almost unintelligible by the lay student or teacher. However, all of these new programs suffered from the curse of complexity (except perhaps BSCS—Tisher et al. (1972) 46-47 argue that BSCS made an effort to reach a broad spectrum of talents, unlike other reform curricula). The designers of reform curricula wanted students to learn pure science but made virtually no effort to make them relevant to the average student (DeBoer, 1991; Kerr & Lester, 1982; Tisher et al., 1972; Ziman, 1980). As these pure programs became more and more unintelligible to the average student, science and mathematics education in the United States began to suffer (Tisher et al., 1972). In addition, the average student was becoming dangerously disillusioned with the science and society in general, and this was impacting performance in the classroom (Tisher et al., 1972). By the mid 1970s, it was clear that something was about to change in science and mathematics education.

In a real sense, science literacy and New Progressivism can be seen as a return to the late Progressive school by science and mathematics educators. Just as the Progressives in the 1920s, science literacy advocates try to look at science and math from the viewpoint of the average student (Ziman, 1980). This perspective then drives the questions which determine the focus of the curriculum. "What math and science does the average person need to be successful in their life? What knowledge is necessary?" (DeBoer, 1991; Ziman, 1980). Ultimately, science literacy advocates determined that the average person needs to know a little about virtually every area of science (Tisher et al., 1972; Ziman, 1980). The average person may not be able to make a toaster, but they could be expected to understand alternating and direct current. The average person may not be able to tell you the mechanism by which a vaccine works, but they could be expected to know what a vaccine does and how it prevents illness (in a general sense) (DeBoer, 1991). Mathematics educators used this idea to push for more applied problems to show students how mathematics could be used in everyday lives.

These ideas might seem to be quite similar to the Commission Report in 1920, and indeed they are. Both the Progressives in 1920 and the science literacy advocates strongly pushed for classes to be relevant in student's everyday lives. However, science literacy advocates also had to manage a new concept—standardized testing. Balancing the memorization and content knowledge necessary for success on standardized tests with the broad base of applied knowledge desired by science literacy advocates has become one of the key tensions of modern science education. Recently, curricula have whipsawed frequently between these two key ideas from year to year, with no single idea gaining true prominence (DeBoer, 1991). Modern thinking is that science education is waiting for an outside catalyst to push the balance in the direction of either science literacy or memorization and content knowledge (Wisseher et al., 2011). This outside catalyst may come in the form of government regulation (such as broader impacts of the No Child Left Behind Act) or in events that people have yet to imagine (another Sputnik-type crisis). In a real sense, science education is very much in flux, with multiple ideas retaining prominence in spite of competition.

Summary and Rationale for Study

Modern educational researchers have demonstrated that the ability of a teacher to implement a curriculum is directly related to the beliefs that an instructor has about teaching in general and teaching science in particular. Moreover, if a curriculum conflicts with the teaching philosophy of instructors, they will have a difficult time implementing this curriculum (Feldman, 2002). In his article, Feldman describes an attempt to implement a constructivist physics curriculum in high schools across the United States. Essentially, he found that teachers naturally use a curriculum which supports their native teaching style and beliefs, and shy away from curricula which are different. A teacher will not, and cannot, change how they teach overnight, even with the adoption of a new curriculum and appropriate workshops on how to use it (Feldman, 2002; Lotter, Harwood, & Bonner, 2006; Yerrick et al., 1997).

The question then arises--what happens if an educational institution adopts a curricula at odds with the teachers' beliefs about teaching and the nature of science? Yerrick and colleagues (1997) found that teachers "fit new messages into their initial set of beliefs." (p. 154). This means that the resulting structure and methods contained in the curriculum actually implemented by the instructors may have very little to do with the intended one. Teachers' beliefs are resistant to change. It is not that the teachers were not trying to change, it is simply that the belief system of the teachers is not able to be torn down and rebuilt in at a moment's notice. Even if teachers are trying to adopt new ideas and internalize them into their belief system, they will naturally do this through the window of their own experiences and perceptions. Therefore, in many cases, the belief structure of an instructor will remain the same, regardless of methods to try to change it (Yerrick et al., 1997).

This means that any new curricula which may be adopted by an educational institution must address the beliefs of the instructors as well as the methods of the curricula (Lotter et al., 2006). Lotter and colleagues (2006) found that when the curriculum aligned with the belief system of the teachers, teachers were able to adopt new practices and use them in the classroom. However, when the curriculum did not align with the belief system of teachers, few substantial changes were made. Lotter et al. (2006) were also unsuccessful in changing the belief structure of their teachers, despite that being the focus of their study.

Clearly, based on the findings of Lotter et al. (2006), knowing an instructor's teaching philosophy is the first step to designing a working curriculum. If one knows that a college's faculty believes teaching to consist of a certain set of actions, then one gives them a curriculum that is completely different, there will clearly be a disconnect. This disconnect may result in an inadequate performance in the classroom.

For teaching to be effective, curriculum must align with teaching philosophy. Current research shows that changing a teacher's core beliefs about teaching is difficult and slow (Lotter et al., 2006; Yerrick et al., 1997). This means that radical curricula that do not align with the majority of instructors' beliefs should not be adopted by an institution. If they are adopted, the institution should recognize going into the situation that very little of the intended ideas will actually survive to the classroom. Note that this is not an active opposition on the part of teachers--teachers simply are unable to adopt practices and methods at odds with their internal belief structure (Lotter et al., 2006). Thus, knowing the teaching philosophy of faculty is the first step to developing a vibrant, effective teaching curriculum. Also, a thorough understanding of teaching philosophy may, for the first time, allow researchers to find a way to successfully shift the beliefs of instructors along the continuum of teaching beliefs discussed previously in this chapter.

CHAPTER III

METHODOLOGY

Introduction

The idea of teaching beliefs is at once simple and complex. Simple, in that they are simply the mindset of a teacher when they are in a classroom setting. Complex, in that these beliefs are composed of many different ideas (Cross, 2009). In science education these ideas include: how people learn about science, how a teacher designs their lessons, how a teacher believes a learning environment should work, and how a teacher believes a science curriculum should be organized (Sampson et al., 2013). Modern research has shown that if a curriculum does not take the beliefs of the teachers implementing it into account, that curriculum will not be successfully adopted in the classroom (Cronin-Jones, 1991). It is the purpose of this study to examine the teaching beliefs of community college instructors--to help community colleges adopt curricula more in line with the beliefs of their instructors and to help community colleges find ways to successfully change the teaching beliefs of their instructors to be in line with their current curricula. Ultimately, this should result in curricula that are embraced in the classroom and successful in teaching students.

Research Design

This project used a quantitative approach with quantitative and a few minor qualitative components to accurately measure the teaching philosophy of the average community college science instructor population of the southeastern United States. The quantitative sections were derived from the BARSTL scale, with added demographic questions to enable accurate comparisons within the population. The BARSTL model and scale were used with permission from Sampson at Florida State University. In addition, four qualitative questions were asked to examine what individually drives the teaching philosophy of participating instructors. Together, these questions strove to give an accurate picture of the teaching philosophy of community college instructors in the Southeastern United States.

Community College Science instructors from across the Southeastern United States were included in this study. Specifically, community college science instructors from Mississippi, Alabama, Louisiana, and Tennessee were included. A mass email targeted specifically at the community college science instructors whose response is desired was used to maximize potential responses to the survey. The survey itself was administered online using Qualtrics, which is an established method of anonymously obtaining responses to surveys with as little disruption as possible to the subjects. The survey remained open for approximately two weeks, to give subjects as much time as possible to respond.

Quantitative analysis of the survey was used to answer both descriptive questions (what is the current average teaching philosophy of a typical community college science instructor?) and more in depth questions (is there a significant relationship between scientific discipline taught and teaching philosophy, for example). Qualitative analysis was used to examine what instructors personally believe formed their teaching philosophy. Qualitative and quantitative responses both from typical representatives of the population as well as outliers were examined to give a broad base for analysis.

Participants

Eleven hundred and three community college instructors were invited to participate in the study at community colleges throughout the Southern United States. 104 of these instructors agreed to participate, with 89 fully completing the survey. All participants were verified to be 18 years of age or older. After successful submission and approval by the Institutional Review Board of The University of Southern Mississippi to conduct research, data collection began (see Appendix D for the Institutional Review Board Application, and Appendix E for the Institutional Review Board Approval Letter).

Instrumentation

A modified version of the BARSTL questionnaire developed by Sampson, Grooms, and Enderle at Florida State and outlined in “Development and Initial Validation of the Beliefs About Reformed Science Teaching and Learning (BARSTL) Questionnaire” (2013) was used in this survey. Sampson granted permission to use the BARSTL for this purpose. BARSTL is an excellent tool for measuring where an individual lies on the continuum of teaching philosophy outlined in previous chapters. Demographic questions were added to the BARSTL to address identified research concerns, as well as an open ended discussion question to allow exploration of interesting responses. The modified questionnaire was given to the participants using Qualtrics and was open for two weeks. At no time was identifying information linking responses to individuals available or accessible.

Procedures

Permission to conduct this research was requested and obtained from The University of Southern Mississippi’s Institutional Review Board. The modified

BARSTL was placed on a website known as Qualtrics so that community college instructors from throughout the Southeast had easy access to it [see Appendix A for a copy of the modified BARSTL]. Qualtrics is a nationally known and respected site for administering surveys online. The site itself is secure and has certificates which certify this. Qualtrics is also 503 Compliant, which means that even if subjects have a disability, they will be able to complete the survey.

After placing the modified BARSTL on Qualtrics, a mass email was sent out inviting community college science instructors from Alabama, Tennessee, Mississippi, and Louisiana to participate in the study [see Appendix C for a copy of the recruitment document]. This email was specifically targeted towards instructors the researcher believed would suit the survey using information gleaned from community college websites. After accessing the survey on Qualtrics, instructors were given details about the study and asked for their consent to participate [see Appendix B for a copy of the consent form]. If they did not give their consent, then they effectively opted out of the survey and could not continue. There was no penalty for an instructor’s failure to participate, and anonymity was retained for all respondents throughout the process.

After opening the survey, it was active on Qualtrics for approximately two weeks, to allow for responses to come in. After that time, the survey was closed. At no time was any identifying information linking responses to individuals accessible. Data was collected from the Qualtrics site itself and permanently deleted after the close of this research.

Delimitations

This study focused on community college science instructors in the Southeastern United States.

Limitations and Discussion

The first limitation to this study is the population sample. Responses were drawn from community college instructors in the Southeastern United States. The results of this study may not be able to be generalized outside of this specific population. In addition, the topic of this survey may be considered by some instructors to be sensitive, especially if they are currently involved in a disagreement with other members of their department in how to teach a topic. This may lead some respondents to respond with what they feel is an “ideal” answer rather than their personal beliefs. Anonymity should help with this issue but will not completely alleviate it.

Justification

This dissertation strove to analyze the teaching philosophy of the typical community college science educator in the southeastern United States. It primarily used the BARSTL questionnaire, developed by Sampson, Grooms, and Enderle to do so (Sampson et al., 2013). From the results, it is hoped to see exactly where the typical community college science instructor lies on the BARSTL continuum of teaching beliefs, and thus be able to help community colleges adopt curricula which maximize the instructors’ ability to grow and successfully perform in the classroom. Another goal was to determine if there are any wide disparities in teaching beliefs of community college science instructors--and if these disparities are tied to any demographic keys. In addition, the origination of these beliefs were explored as well as potentially how these beliefs were formed.

Data Analysis

Descriptive analysis will be used to address the following research questions:

- Where does the average community college science instructor in the Southeastern United States lie on the BARSTL continuum? Does the average instructor have a traditional discipline-focused approach or a constructivist student-centered approach?
- Where is the average instructor placed in the individual BARSTL categories: how people learn about science, lesson design and implementation, characteristics of teachers and the environment, and the nature of the science curriculum?

Statistical analysis will be used to address the following research questions:

- Is there a significant relationship between teaching philosophy (BARSTL score) and the number of hours an instructor teaches in a semester? Is there a significant difference between BARSTL components and the number of hours an instructor teaches in a semester?
- Is there a significant relationship between teaching philosophy (BARSTL score) and years of teaching experience? Is there a significant difference between BARSTL components and years of teaching experience?
- Is there a significant relationship between teaching philosophy (BARSTL score) and age of the instructor? Is there a significant difference between BARSTL components and age of the instructor?
- Is there a significant relationship between teaching philosophy (BARSTL score) and the specific science which is primarily taught by an instructor? Is there a significant

difference between BARSTL components and the specific science which is primarily taught by an instructor?

- Is there a significant relationship between teaching philosophy (BARSTL score) and the state in which an instructor teaches? Is there a significant difference between BARSTL components and the state in which an instructor teaches?
- Is there a significant relationship between teaching philosophy (BARSTL score) and birth order of the instructor? Is there a significant difference between BARSTL components and birth order of the instructor?

Qualitative and quantitative analysis will be used to address the following research questions:

- What do community college science instructors believe is the driving force behind making their discipline change? Is it driven by discoveries within the discipline? Is it driven by outside forces, such as politics?
- Do community college instructors change their approach in the classroom after they begin teaching?
- Do community college instructors believe their teaching style impacts how well their students learn in the classroom?
- Do community college instructors believe that all of the instructors in a department should use a similar teaching style?

Data will be initially analyzed using descriptive statistics and frequency analysis. The descriptive questions will be addressed using these descriptive statistics and frequency analysis. Statistical questions will then be addressed using a series of ANOVAs to determine the relationship between the question and overall BARSTL score, then a series of MANOVAs to determine the relationship between the question and BARSTL subscores. Finally, the qualitative questions will be addressed by coding of the responses, and then a repetition of the quantitative steps. The qualitative questions will also be investigated in more detail to see if the instructors themselves brought up points not considered here.

Summary

In summary, the goal of this study is to see if there is a specific demographic marker (number of hours taught, years of teaching experience, age, specific science taught, state, birth order) which an institution can use to predict the teaching philosophy of a college instructor. To do this statistical tests will be used to try to find a significant relationship between BARSTL scores and various potential demographic markers. In addition, this study will also look more closely at what instructors themselves believe have formed their own teaching philosophy. This topic will be examined by coding qualitative responses given on the survey and looking at the results. These results may also be cross-referenced with the quantitative results to see the relationship therein. The results of this study will allow institutions to better understand their faculty and adopt curricula that are more closely aligned with the teaching beliefs of their faculty. Alternatively, these results may be used as the beginning of devising a method to successfully change teaching beliefs to ones more compatible with the curriculum currently in use. Though altering teaching beliefs has been unsuccessful in the past, the knowledge gained in this study should help to begin to change that. Together, these ideas should ultimately allow adopted curricula to be successful in the classroom, and so benefit the student population greatly.

CHAPTER IV

RESULTS

The overall purpose of this dissertation was to analyze the teaching philosophy of the typical community college science educator in the southeastern United States, by applying the Beliefs About Reformed Science Teaching and Learning (BARSTL) questionnaire, developed by Drs. Sampson, Grooms, and Enderle (Sampson et al., 2013). From the results, it is hoped to see exactly where the typical community college science instructor lies on the BARSTL continuum of teaching beliefs, and thus be able to help community colleges adopt curricula which maximize the instructor's ability to grow and successfully perform in the classroom. Further, the ultimate goal was to determine if there were any wide disparities in teaching beliefs of community college science instructors--and if these disparities were tied to any demographic keys.

Data was collected from community college science instructors from across the Southeastern United States using a targeted email linked to the Qualtrics.com website. 1103 emails were sent to community college science instructors in Alabama, Louisiana, Mississippi, and Tennessee. One hundred and twenty instructors began the survey, and 90 completed it. Of those 120 responses, 81 were ultimately included in the study (N=81). Criteria for inclusion in the study were that the given survey needed to be over 75% complete, with no more than 25% missing from any subscale area of the BARSTL. Essentially, this meant that respondents skipped/marked no response to no more than two questions in each of the four BARSTL subscales.

As shown in Table 1, respondents came from every state, with 10 each coming from Alabama and Louisiana (12.8%), 18 from Tennessee (23.1%), and 39 coming from

Mississippi (50%). Respondents also came from a wide variety of scientific fields. As shown in Table 2, 29 respondents taught Biology (37.2%), 7 taught Chemistry (9%), 31 taught Mathematics or Computer Science (39.7%), and 9 taught Physics or Physical Science (11.5%).

Table 1

Frequency Statistics by State

		Frequency	Valid Percent
Valid	Alabama	10	12.5
	Louisiana	12	15.0
	Mississippi	40	50.0
	Tennessee	18	22.5
	Total	80	100.0
Missing	System	1	
Total		81	

Table 2

Frequency Statistics by Science Taught

		Frequency	Valid Percent
Valid	Applied Sciences	2	2.5
	Biology	29	35.8
	Chemistry	7	8.6
	Computer Science	5	6.2
	Mathematics/statistics	27	33.3
	Physics/physical science	11	13.6
	Total	81	100.0

Findings

This study consisted of three related sections. First, the BARSTL questionnaire was administered to the respondent to measure their placement on the continuum of teaching beliefs. This questionnaire consisted of four subsections: how people learn, lesson design and implementation, teachers and the learning environment, and the science curriculum. The BARSTL itself was scored using a method described in the next section. Scores on the BARSTL range from 32 to 128, with higher scores representing a constructivist student-centered attitude, and lower scores representing a teacher focused lecture-oriented attitude toward teaching. A score of 80 represents a balanced approach, a belief that elements of both lecture and constructivist teachings are effective.

Second, a series of demographic were asked of the respondents. These questions included: hours taught (full/part time), age, teaching experience, subject taught, state, and birth order. These questions were asked to see if there was any relationship among any of these factors and the BARSTL score. This relationship was explored using statistical methods, as discussed in the next section. In addition, any commonalties in the respondents that might skew the results would also be apparent in the results of the demographic questions.

Third, a series of short answer questions were asked of the respondents. These questions included: what makes your discipline change?; have you changed your approach since you started teaching?; does your teaching style impact how your students learn?; and should all instructors in a department use a similar teaching style? These questions were asked for two reasons.

The first reason the short answer questions were asked is that they give an insight into the mindset of the respondent and allow for more detailed interpretation of the BARSTL score. For example, an instructor may be constructivist but believe that their teaching method has no real impact on how students learn in the classroom (which was the response given by a respondent). This gives rise to many questions, such as why? Is the instructor taking the approach they feel most comfortable with, or do they think their approach is at fault? In this particular case, the instructor believed that if students did not apply themselves, no approach would be successful, and that the instructor played only a small role. More will be discussed about this particular example later, in the short answer section.

The second reason short answer questions were asked is that they allow for a broader analysis of the respondents as a whole. To this end, the most common responses were coded, and statistical analysis was conducted on them to see if there was any relationship between particular responses and BARSTL score.

Quantitative analysis of the demographic questions as well as the coded short answer questions was conducted using SPSS (versions 20 and 22). Analysis of the relationship between overall BARSTL score and the 10 demographic and short answer factors (hereafter called factors) was done using a one-way ANOVA in SPSS. Necessary follow-up analysis, including post hoc tests, were done where significance was found. Analysis of the relationship between the four BARSTL sub-sections and the factors was done using a one-way MANOVA in SPSS. Necessary follow up analysis, including post hoc tests and discriminant analysis were done where significance was found.

For each statistical test, steps were taken to verify the assumptions necessary for these statistical tests to be accurate. In general, note that the BARSTL score and its subscores are interval variables, while each measured factor has categorical responses, satisfying base assumptions for the MANOVA and ANOVA. In addition, there is independence of observations because only one answer was allowed in each factor. The overall sample size is quite sufficient; however, certain categories needed to be combined so that they could be analyzed, since by assumption MANOVAs and ANOVAs cannot use categories with less members than our number of dependent variables. Which categories were combined will be discussed in the analysis, but this was only used for categories with very small membership ($n<5$).

Both univariate and multivariate outliers were also addressed in this study. Calculation of Mahalanobis distance showed that there were no multivariate outliers in the BARSTL subscale. However, calculations of Z-scores of the BARSTL score and subscores found three outliers. One member of the first subscale had a Z-score of 3.23, and two members of the fourth subscale had a Z-score of 3.69. Any Z-score of +/- 3 is considered suspect, and these three scores not only were outliers, but were two points away from the next largest Z-scores in their subscale. For this reason these three subscale scores responding to these z-scores were removed from study and not included in our discussion. Interestingly, though these three subscale scores were outliers, the associated BARSTL scores in those cases were not outliers and fell within the +/-3 range for consideration in the study.

An independent sample t-test was conducted to allow comparison of the BARSTL scores and subscores for each question in order to establish the use of equivalent groups. This test was significant for questions 37 and 38 indicating no homogeneity of variance between groups for these questions. All other tests were not significant indicating homogeneity of variance between groups.

Scoring of the BARSTL

The BARSTL was constructed as follows. Exactly one half of the BARSTL questions measure how constructivist an instructor is from a scale of 1 to 4, with 4 being constructivist and 1 more traditionalist. Questions 3, 4, 6, 7, 11, 12, 15, 16, 18, 21, 22, 23, 26, 27, 29, and 31 measured exactly the same topic in the opposite manner, with 1 being constructivist and 4 more traditionalist. Mixing question types allowed for more accurate results and follows the standard set by Sampson, Grooms, and Enderle in their initial paper (Sampson et al., 2013).

To score the BARSTL, the results of each question were summed, with the traditionalist questions being scored in reverse (a 4 on a traditionalist question is worth only 1 point, and so on). This results in a possible score of 8 to 32 on each of 4 BARSTL sections, or 32 to 128 overall BARSTL score. A score of 80 as an overall BARSTL score can be considered average, with no real leanings toward either constructivist teaching or more traditional lecture based teaching.

Missing answers from surveys that were included were imputed before the summation stage by taking the average of the scores in the missing score's subsection. Since no more than two scores were allowed to be missing in any subsection of the BARSTL, this ensured that an accurate result was maintained for the BARSTL.

BARSTL scores and BARSTL Subscales

The mean overall BARSTL score for tested group (N = 81) was 84.4. The minimum score was 70 with a high of 105. Other descriptive statistics for the overall BARSTL score are given in Table 3. One interesting fact to note is that both skewness and kurtosis for the overall BARSTL score were moderate, meaning that the BARSTL has close to a normal distribution. A histogram for the overall BARSTL score is given in Figure 1. Also note that the mean of the BARSTL (84.4) is slightly more than a score implying neutral teaching beliefs incorporating both constructivist and more traditional lecture based teaching (80), meaning that community college science instructors tend to be slightly more constructivist than lecture based. Generally though, community college science instructors can be viewed overall to have balance in their teaching beliefs, incorporating both student centered and instructor centered beliefs. However, the maximum of overall BARSTL score is quite high, which means that some instructors were quite constructivist, while no instructors were lecture focused to a similar degree.

Table 3

Descriptive Statistics for Overall BARSTL Score

		OVERALL BARSTL SCORE
N	Valid	81
	Missing	0
Mean		84.4
Median		83.7
Std. Deviation		7.3
Variance		53.4
Skewness		.728
Kurtosis		.557
Minimum		70.0
Maximum		105.0

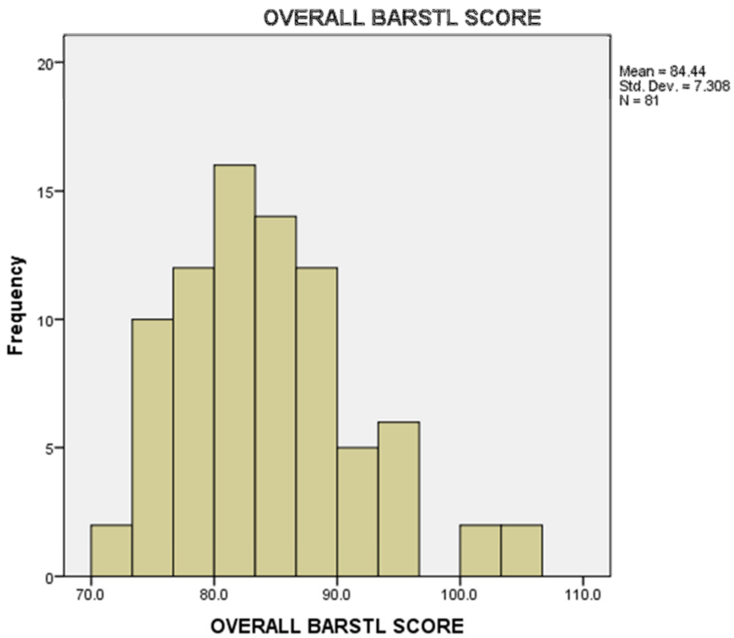

Figure 1. Histogram for Overall BARSTL Score.

The BARSTL subscores showed similar behavior as the overall score. Means of the tested group (N=81) ranged from 20 to 21, close to the mean of a balanced belief system, which would be 20. Other descriptive statistics for the BARSTL subscores are given in Table 4. Note that subscores I through III have a fairly wide range (11-14) with minimal skewness and kurtosis. Subscore IV has a much smaller range (5) with more significant kurtosis. Figures 2 through 5 show histograms for the BARSTL subscores.

Table 4

Descriptive Statistics for BARSTL Subscores

	I. How People Learn About Science	II. Lesson Design and Implementation	III. Characteristics of Teachers and the Learning Environment	IV. The Nature of the Science Curriculum
N Valid	80	81	81	79
Missing	1	0	0	2
Mean	20.6	20.9	21.4	21.3
Median	20.8	21.0	21.0	21.0
Std. Deviation	2.7	2.6	2.7	1.5
Variance	7.2	6.9	7.1	2.1
Skewness	.267	.406	.227	.315
Kurtosis	-.329	.201	.112	-.827
Range	11.4	13.0	14.0	5.3
Minimum	16.0	15.0	15.0	18.7
Maximum	27.4	28.0	29.0	24.0

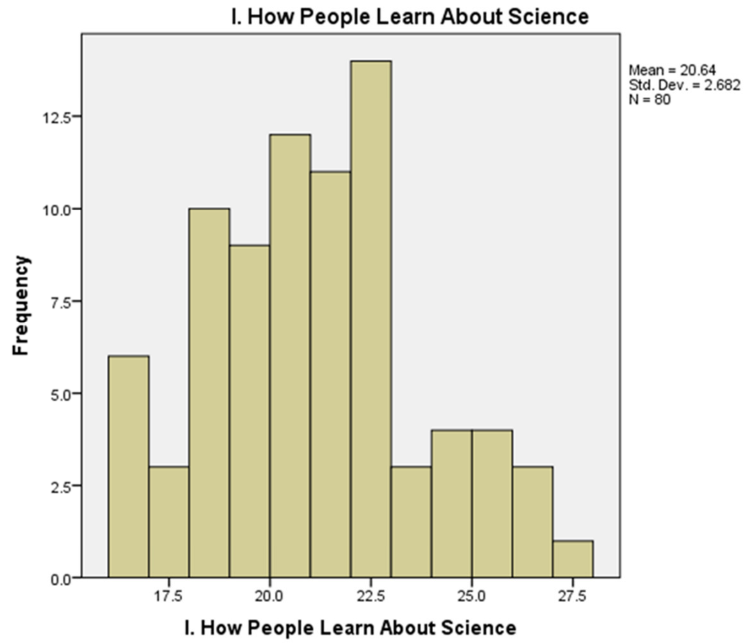

Figure 2. Histogram for BARSTL Subscale I.

Figure 3. Histogram for BARSTL Subscale II.

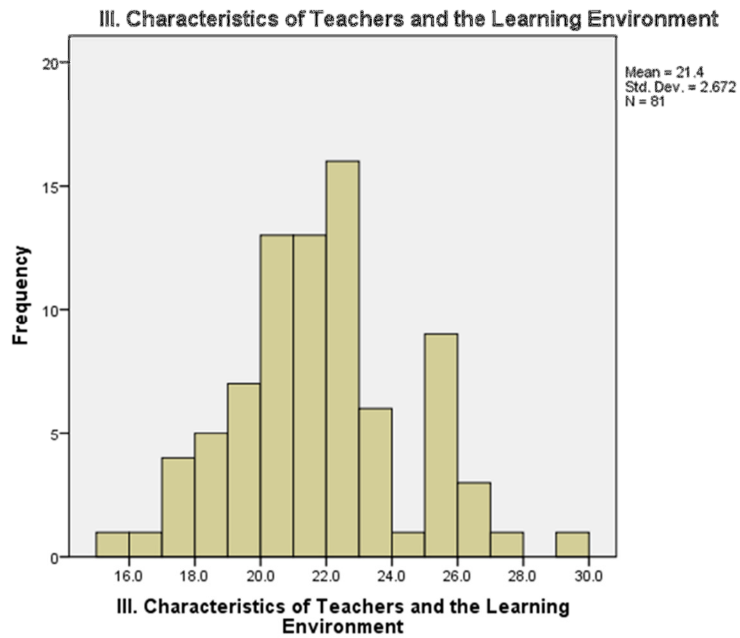

Figure 4. Histogram for BARSTL Subscale III.

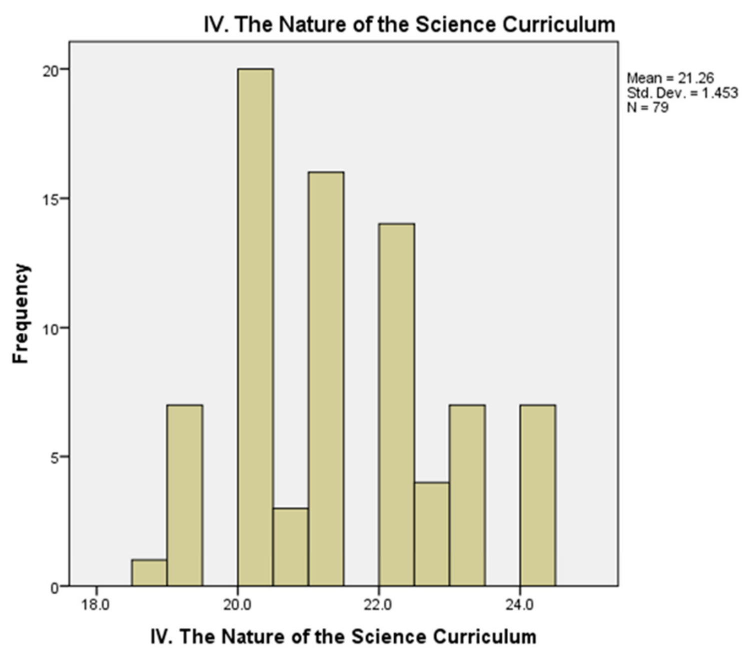

Figure 5. Histogram for BARSTL Subscale IV.

Demographic Questions

Question 37: Hours Taught in the Classroom

Question 37 of the questionnaire addressed the number of hours spent teaching by an instructor. A full-time community college instructor can be expected to teach at least 15 hours a week in the classroom (some much more), while a part-time instructor may teach much less. Frequency data for Question 37 is given in Table 5. Note that the majority of instructors who participated in the study taught at least 16 hours a week (N=57), so they can be considered full-time employees.

Table 5

Frequency Data for Question 37: Hours Taught in the Classroom

		Frequency	Valid Percent
Valid	1-3	1	1.3
	4-9	6	7.5
	10-15	16	20.0
	16+ hours	57	71.3
	Total	80	100.0
Missing	5	1	
Total		81	

Overall BARSTL score. Analysis was performed to see if there was a significant relationship between hours taught and overall BARSTL score. In order to meet the base assumptions of the ANOVA, the 1-3 hour category (N=1) was combined with the 4-9 hour category (N=6). Here, the one-way between-subjects analysis of variance failed to reveal a major effect of hours taught in the classroom on the overall BARSTL score, $F(2,77)=1.222$, $p=.300$, $\alpha=.05$. Note also that question 37 failed Levine's homogeneity of variance test, $p=.021$, $\alpha=.05$. A means plot giving the relationship between hours taught and overall BARSTL score can be seen in Figure 6. There appears to be a difference between an instructor who teaches only a few classes and a full-time instructor, but not a significant one.

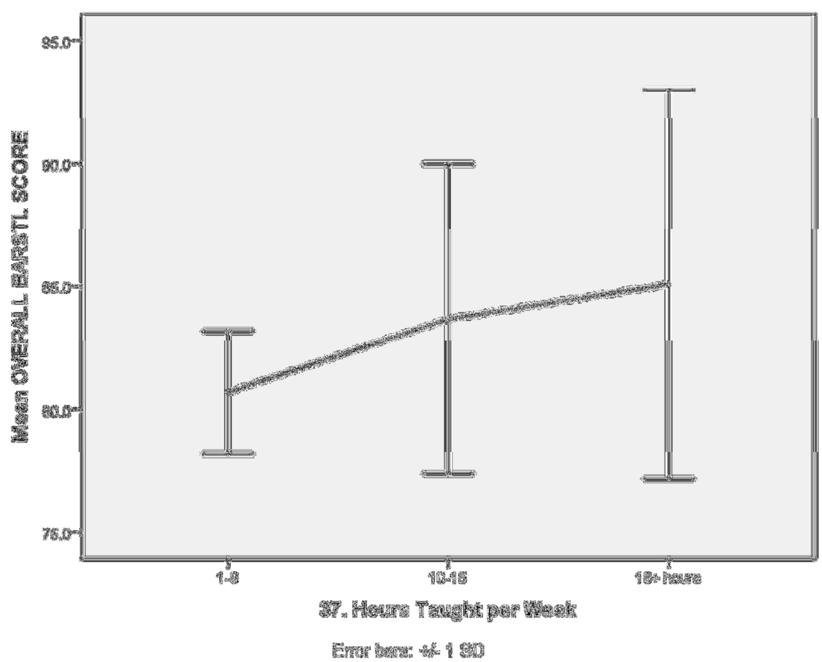

Figure 6. Means plot of Question 37: Hours Taught and BARSTL Score.

Significance by section of BARSTL. Analysis was also performed to see if there was a significant relationship between hours taught and BARSTL score components. Again, the 1-3 hour category (N=1) was combined with the 4-9 hour category (N=6) to meet base assumptions for the MANOVA. Here, the one-way multivariate analysis of variance failed to reveal a major effect of hours taught in the classroom on any of the components of the BARSTL score, $F(8, 296)=.432$, $p=.900$, Wilk's $\lambda=.953$, partial eta squared=.024, $\alpha=.05$.

Question 38: Years of Teaching Experience

Question 38 of the questionnaire asked respondents their number of years of teaching experience. This category is related to, but different from, question 39, age of the respondent. Many community college instructors come to this profession as a second line of work, after either time in industry or teaching at another level (high school or four year college). Frequency data for Question 38 is given in Table 6. While the majority of instructors have 16 or more years of experience, a wide variety of teaching experience can be found in the respondents. Note that only a few instructors have less than 3 years of teaching experience (N=3).

Table 6

Frequency Data for Question 38: Years of Teaching Experience

		Frequency	Valid Percent
Valid	0-2 years	3	3.7
	3-5 years	9	11.1
	6-10 years	14	17.3
	11-15 years	19	23.5
	16+ years	36	44.4
	Total	81	100.0

Overall BARSTL score. Analysis was performed to see if there was a significant relationship between years of teaching experience and overall BARSTL score. In order to meet the base assumptions of the ANOVA, the 0-2 year category (N=3) was combined with the 3-5 year category (N=9). Here, the one-way between-subjects analysis of variance failed to reveal a major effect of years of teaching experience on the overall BARSTL score of the respondents, $F(3,77)=2.425$, $p=.072$, $\alpha = .05$. Note also that question 38 failed Levine's homogeneity of variance test, $p=.042$, $\alpha = .05$. As Figure 7 shows, there was no clear relationship demonstrated in the means plot of years of teaching experience and BARSTL score.

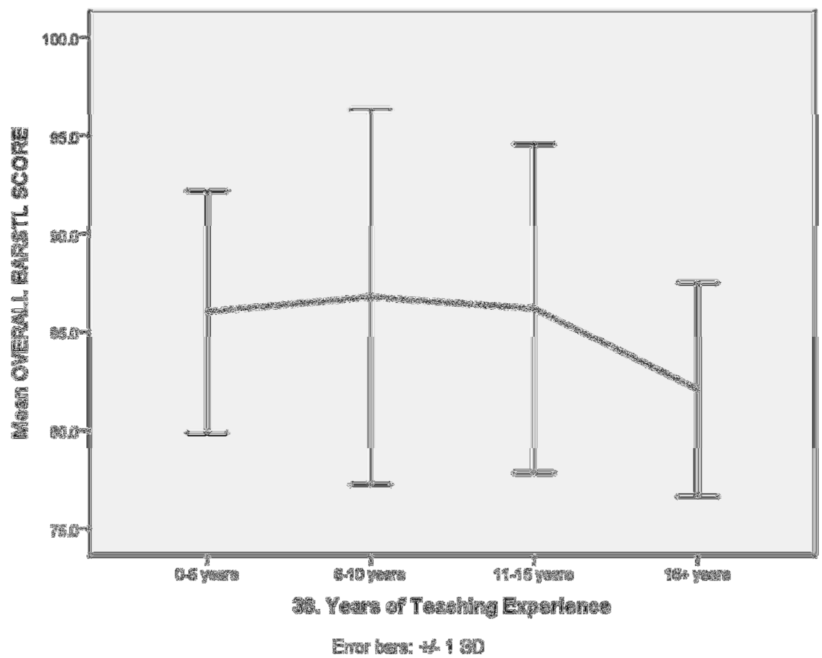

Figure 7. Means plot of Question 38: Years of Teaching Experience and BARSTL score.

Significance by section of BARSTL. Analysis was also performed to see if there was a significant relationship between years of teaching experience and BARSTL score components. Here, the one-way multivariate analysis of variance failed to reveal a major effect of years of teaching experience on any of the components of the BARSTL score, $F(8, 296)=.898$, $p=.550$, Wilk's $\lambda=.863$, partial eta squared=.048, $\alpha = .05$.

Question 39: Age

Question 39 of the questionnaire dealt with the age of the respondent. Because community college instructors often take up this career later in life, age is considered a different category than years of teaching experience. Frequency data for Question 39 is given in Table 7. The distribution was fairly even throughout, though only a few respondents were age 65 or older.

Table 7

Frequency Data for Question 39: Age

		Frequency	Valid Percent
Valid	21-35 years	19	23.5
	36-49 years	23	28.4
	50-64 years	34	42.0
	65+ years	5	6.2
	Total	81	100.0

Overall significance. Analysis was performed to see if there was a significant relationship between age of the respondent and overall BARSTL score. Here, the one-way between-subjects analysis of variance revealed a significant effect of age on the overall BARSTL score, $F(3,77)=3.861$, $p=.013$, $\alpha = .05$. These results can be seen in Table 8.

Table 8

ANOVA Results for Question 39: Age

ANOVA					
OVERALL BARSTL SCORE					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	558.667	3	186.222	3.861	.013
Within Groups	3714.074	77	48.235		
Total	4272.742	80			

A Tukey post hoc test was performed to examine the significant relationship between age and BARSTL score. A significant relationship was found to exist between the two age categories 21-35 years, and 50-64 years (p=.013). No significant relationship was found to exist between the other groups, though the relationship of the 65+ group to the 21-35 year group was interesting (p=.100). This information can be seen in Table 9.

Table 9

Tukey post hoc test for Question 39: Age

	(I) 39.Age	(J) 39.Age	Mean Difference (I-J)	Std. Error	Sig.
		36-49 years	3.5	2.2	.369
Tukey HSD	21-35 years	50-64 years	6.2	2.0	.013
		65+ years	8.1	3.5	.100

Table 9 (continued).

	(I) 39.Age	(J) 39.Age	Mean Difference (I-J)	Std. Error	Sig.
		21-35 years	-3.5	2.2	.369
	36-49 years	50-64 years	2.69	1.9	.482
		65+ years	4.63	3.4	.533
		21-35 years	-6.20	2.0	.013
Tukey HSD	50-64 years	36-49 years	-2.7	1.9	.482
		65+ years	1.9	3.3	.936
		21-35 years	-8.1	3.5	.100
	65+ years	36-49 years	-4.6	3.4	.533
		50-64 years	-1.9	3.3	.936

An easier way to see this relationship is by using a means plot. Figure 8 gives a means plot of age category to BARSTL score. There exists a clear linear relationship between Age and BARSTL score. As an instructor becomes older, their views are less student centered and more balanced between a student and instructor focus. This relationship will be explored further in Chapter V.

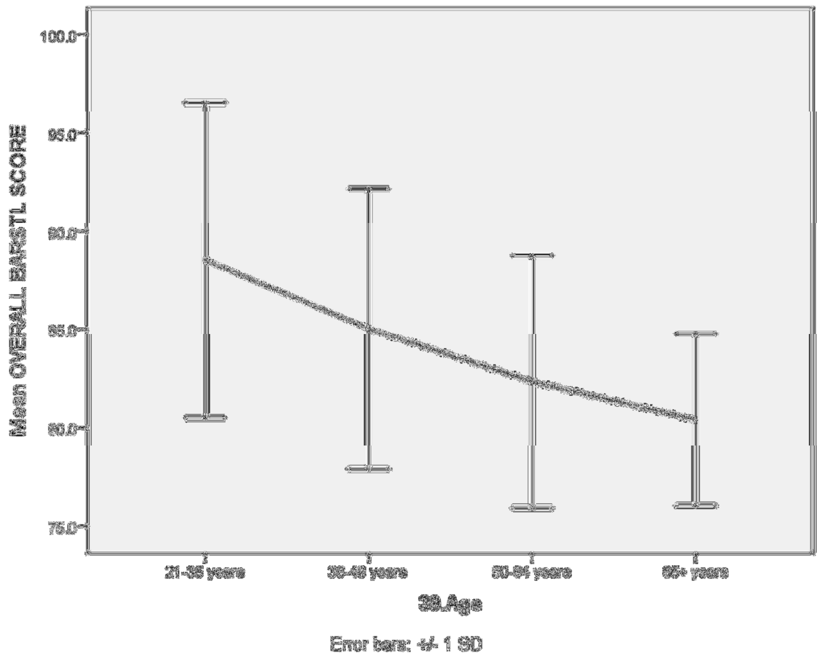

Figure 8. Means plot of Question 39: Age and BARSTL score.

Significance by section of BARSTL. Analysis was also performed to see if there was a significant relationship between age of the respondent and BARSTL score components. Here, the one-way multivariate analysis of variance failed to reveal a significant effect of age of the respondent on any of the components of the BARSTL score, $F(8, 300)=1.146$, $p= .325$, Wilk's $\lambda=.830$, partial eta squared=.060, $\alpha=.05$.

Question 40: STEM Field Taught by an Instructor

Question 40 of the questionnaire dealt with the STEM field taught by an instructor. Community colleges teach a wide variety of STEM subjects, from the traditional mathematics courses to specialized Biology and Chemistry courses for both academic students and workforce development students continuing on to specialize in a particular field. Frequency data for Question 40 is given in Table 2. Note that only a few instructors identified themselves as Applied Sciences instructors (N=2)--most instructors identified themselves with a particular field of study.

Overall significance. Analysis was performed to see if there was a significant relationship between STEM field taught by an instructor and overall BARSTL score. In order to meet the base assumptions of the ANOVA, the Applied Sciences category (N=2) was treated as missing and not part of the analysis. Here, the one-way between-subjects analysis of variance failed to reveal a major effect of STEM field taught by an instructor on the overall BARSTL score, $F(4,74)=1.239$, $p=.302$, $\alpha = .05$. Figure 9 gives the means plot between STEM field taught by an instructor and overall BARSTL score. There appear to be some differences between chemistry and mathematics and the other sciences, but no significant differences were found.

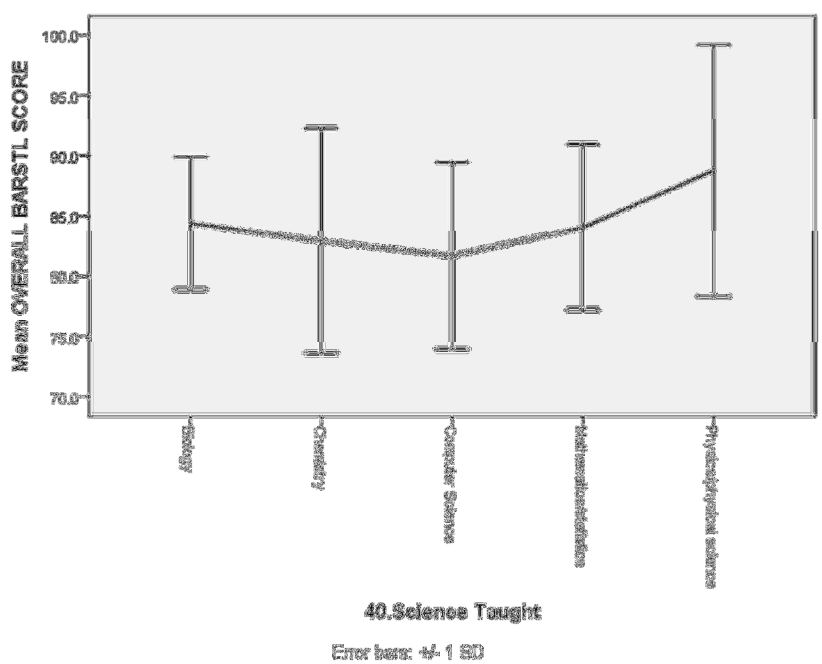

Figure 9. Means plot of Question 40: Science Taught and BARSTL score.

Significance by section of BARSTL. Analysis was also performed to see if there was a significant relationship between STEM field taught by an instructor and BARSTL score components. Again, in order to meet the base assumptions of the ANOVA, the Applied Sciences category (N=2) was treated as missing. Here, the one-way multivariate analysis of variance failed to reveal a significant effect of the STEM field taught by an instructor on any of the components of the BARSTL score, F(16, 284)=.819, p=.663, Wilk's λ=.830, partial eta squared=.046, $\alpha = .05$.

Question 41: State of Residence

Question 41 of the questionnaire dealt with the state in which an instructor lives. This survey was sent to 200-300 instructors in each of Alabama, Mississippi, Louisiana, and Tennessee. Frequency data for Question 41 is given in Table 1. Most respondents were from the state of Mississippi--this is likely because the letter attached to the survey referenced The University of Southern Mississippi and community colleges in the state of Mississippi.

Overall significance. Analysis was performed to see if there was a significant relationship between state of residence and overall BARSTL score. Here, the one-way between-subjects analysis of variance failed to reveal a major effect between state of residence on the overall BARSTL score, F(3,76)=.269, p=.848, $\alpha = .05$. Figure 10 gives a mean plot showing state of residence and overall BARSTL score. Though instructors in Louisiana tended to be more constructivist, the difference was not significant.

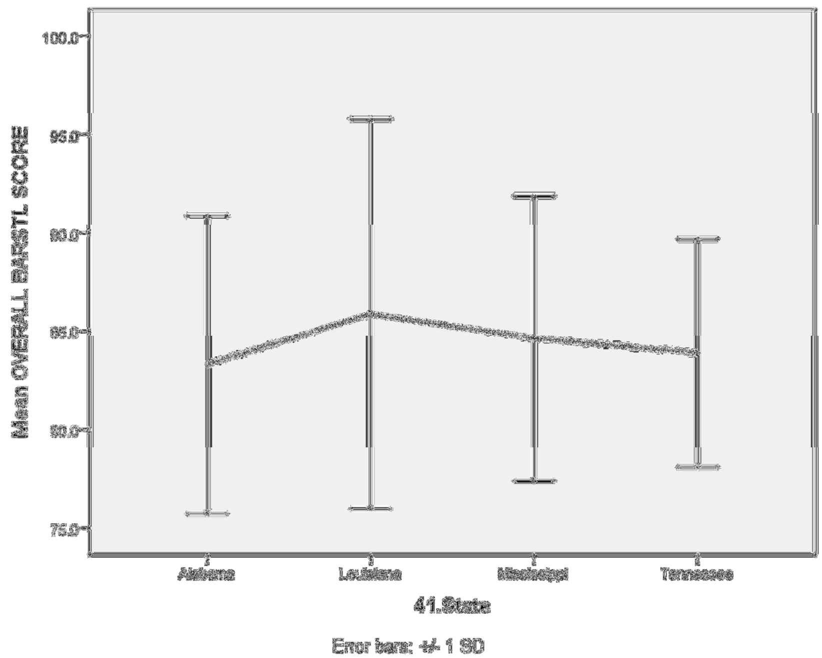

Figure 10. Means plot of Question 41: State of Residence and BARSTL Score.

Significance by section of BARSTL. Analysis was also performed to see if there was a significant relationship between state of residence and BARSTL score components. Here, the one-way multivariate analysis of variance failed to reveal a significant effect of state of residence on any of the components of the BARSTL score, $F(12, 292)=1.286$, $p=.229$, Wilk's $\lambda=.809$, partial eta squared=.068, $\alpha=.05$.

Question 42: Birth Order

Question 42 of the questionnaire dealt with the birth order of the respondent. This question was another attempt to examine if there exist any commonalties in teaching beliefs between members of certain demographics. Frequency data for Question 42 is given in Table 10. It is interesting to note that most respondents were the oldest child in their family.

Table 10

Frequency Data for Question 42: Birth Order of Instructor

		Frequency	Valid Percent
Valid	Only child	7	8.8
	Youngest child	25	31.3
	Middle child	12	15.0
	Oldest child	36	45.0
	Total	80	100.0
Missing	5	1	
Total		81	

Overall significance. Analysis was performed to see if there was a significant relationship between birth order and overall BARSTL score. Here, the one-way between-subjects analysis of variance failed to reveal a major effect between birth order on the overall BARSTL score, $F(3,76)=.590$, $p=.623$, $\alpha = .05$. Figure 11 shows a means plot of birth order and overall BARSTL score. Though a difference was seen between oldest/youngest children and the other groups, the difference was not significant.

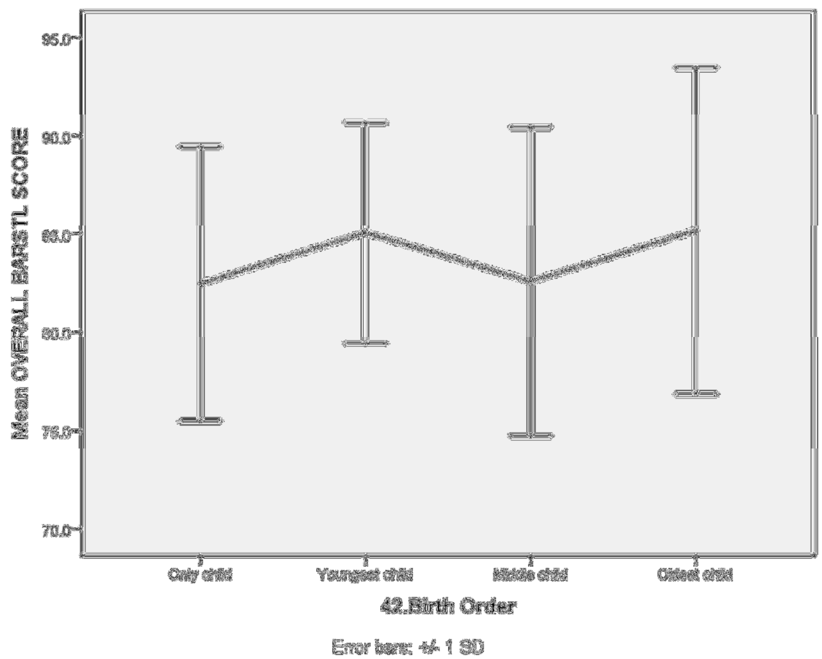

Figure 11. Means plot of Question 42: Birth Order and BARSTL score.

Significance by section of BARSTL. Analysis was also performed to see if there was a significant relationship between birth order and BARSTL score components. Here, the one-way multivariate analysis of variance failed to reveal a significant effect of birth order on any of the components of the BARSTL score, $F(12, 292)=.780$, $p=.670$, Wilk's $\lambda=.878$, partial eta squared=.043, $\alpha=.05$.

Free Response Questions

Four free response questions were also included as part of the survey. These questions attempted to gain insight into why instructors believe what they do, as well as examine any significant relationship between these particular beliefs and overall attitude toward constructivist teaching (as measured by BARSTL score). These free response questions were analyzed in two ways.

First, instructors' responses were coded into the three or four most common answers, and quantitative analysis was performed upon these answers. This quantitative analysis may include an ANOVA to examine the relationship between answers and overall BARSTL score, as well as a MANOVA to examine the relationship between responses and BARSTL subscores. For two of the questions, responses did not lend themselves to this type of analysis--in one, a t-test was appropriate, for the other, the overwhelming majority of instructors selected the same response, which limited the statistical analysis necessary.

Second, individual responses from instructors were examined--not only to see the thought process behind their answers, but to see if their responses can give new insight into their belief structure. This portion of the survey was quite informative, in that many instructors wrote eloquently about their beliefs. Their writings will be examined below.

Question 33: What drives your discipline to change?

Question 33 of the questionnaire asked respondents what they thought drove their discipline to change. The actual text of the question was as follows:

> What do you believe is the principal driving force behind making your discipline change? Is it driven by discoveries within your discipline, such as new theories or techniques? Is it driven by outside forces, such as politics?

There were three common responses to this question, so these responses were coded for analysis. These responses were as follows:

1. My discipline is primarily driven by politics and political forces.
2. My discipline is primarily driven by technology.
3. My discipline is primarily driven by discoveries and change from within the discipline.

Frequency data for these responses is given in Table 11.

Table 11

Frequency Data for Question 33: What drives your discipline to change?

		Frequency	Valid Percent
Valid	Driven by Politics	28	49.1
	Driven by Technology	13	22.8
	Driven by Discoveries	16	28.1
	Total	57	100.0
Missing	4	24	
Total		81	

Of particular note in the frequency data is the comparatively large number of respondents who did not give a response or did not understand the question. Most of the respondents who indicated that they did not understand the question were undecided whether their discipline was science or science education. In addition, virtually all of the respondents who responded with an answer of the (3) variety believed that their discipline was science: biology, mathematics, etc. On the other hand, all of the respondents who responded (1) believed that their discipline was science education. (2) respondents were split between these groups. These differences will be discussed further below.

Quantitative analysis of coding. Analysis was performed to see if there was a significant relationship between the driving force behind a discipline and overall BARSTL score. Here, the one-way between-subjects analysis of variance failed to reveal a major effect between the driving force behind a discipline on the overall BARSTL score, $F(2,54)=.234$, $p=.792$, $\alpha = .05$. Figure 12 shows a means plot of the driving force behind a discipline and overall BARSTL score.

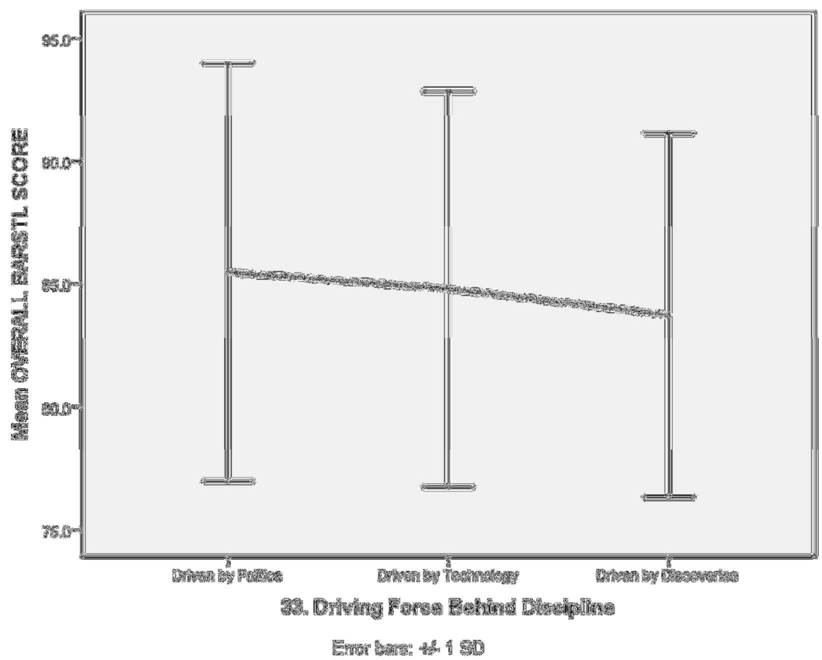

Figure 12. Means Plot of Question 33: Driving Force Behind Discipline and BARSTL Score.

Of interest in Figure 12 is the observation that instructors who believe their discipline is driven by politics have a higher BARSTL score than those who believe their discipline is driven by discoveries, though this difference is not significant. Also note that it might be an interesting research question to examine whether BARSTL score is related to whether an instructor believes themselves to be a “scientist” or a “science educator.”

Analysis was also performed to see if there was a significant relationship between the driving force behind a discipline and BARSTL score components. Here, the one-way multivariate analysis of variance failed to reveal a significant effect of between the driving force behind a discipline on any of the components of the BARSTL score, $F(12, 204)=1.378$, $p=.216$, Wilk's $\lambda=.805$, partial eta squared=.103, $\alpha=.05$.

Discussion. The most popular response to this question was (1) that the respondents' discipline was driven by politics and outside forces. Investigating these responses in depth reveals that instructors are not happy with the significant influence politics has on the classroom--many of these instructors cited from arguments in the K-12 arena concerning the Common Core and political influence in the classroom. Instructors note that corporations and especially textbook companies are using their influence to change course content. One interesting response was given by a mathematics instructor trying to compare a view of science education with a view of science in general:

> I believe that it is driven by politics. Unfortunately, there is a hidden agenda that no one really wants to talk about because it is not politically correct. Public school children--and adults--are only exposed to the THEORY of evolution (and associated theories like the Big Bang) and those supposedly scientific theories are taught as LAW. Those who do not believe in the existence of a creator have succeeded in pushing creationism out of curricula because it has an association with recognized religions. They devoutly refuse to admit that Creationism takes no more faith than believing in Evolutionary Theories. The atheist's god is himself or science or anything that is considered “not religious.” In

> contrast, discipline change should be driven by discoveries both inside and outside the "scientific world."

Clearly, this instructor is torn between personal beliefs and what they believe should be taught in the classroom. This internal conflict clearly has the instructor confused, even though it is taking place in a discipline outside of the instructor's own. Note that this instructor's BARSTL score is 91, which implies a constructivist attitude in the classroom (a neutral attitude with no preference would have a score of 80). One can imagine how lively the discussions might be in this instructor's class. This response shows how scientific arguments from one discipline can affect the belief systems of science educators in a different discipline.

Another common response to this question was (2) that the respondents' discipline was primarily driven by technology and changes in technology. This idea was held by both instructors who believed themselves to be scientists as well as those who believed themselves to be science educators, though the reasoning behind each were quite different. Respondents commented that changes in technology have caused them to radically change how they teach in the classroom. Respondents also commented that technology is fundamentally changing their science as well. A typical response given by a biology instructor viewing themselves as a biologist highlighting this idea is given below:

> While there is a constant stream of new information, I believe the driving force behind changes within the field of biology is progress on a technology front. Not only does the technology allow us to answer questions we could not answer

> previously, it also demands a new way of thinking about some of the previous knowledge that has been reported.

To this instructor, technology is allowing questions to be answered now that have not been able to be answered before. Clearly, this instructor believes biology to be a changing and evolving discipline. One might think that this would translate to a constructivist attitude in the classroom, and this instructor does indeed have a BARSTL score of 89 (as compared to a neutral score of 80).

However, some instructors see a darker side to the influence of technology in the classroom. Another biology instructor also believed technology to be the guiding influence in their discipline, but their reasons why were quite different:

> My challenge is calculators. While technological advances are great, students have become so dependent on calculators that they cannot perform simple calculations without them.

This instructor worries that technology is damaging their students' abilities to do calculations. This instructor views overdependence on technology to be harmful, especially in disciplines where technology can perform much of the "work" typically done by students. Note that this attitude is held by a more lecture-oriented instructor, with a BARSTL score of 76.

The final response to this question was (3) that the respondent's discipline was primarily driven by discoveries within their field. This idea was most often held by instructors who saw themselves as scientists. This is the classical view--that science progresses and grows through discoveries and application of the scientific method. A typical response of an instructor viewing their science in this way is as follows:

> I believe the main driving force is discoveries within a given field. Especially in newer sciences such as biochemistry. The field is constantly changing because of all the new knowledge coming in. New technology can also help us make new discoveries, as well as aid in student learning by incorporating them into the classroom.

This instructor sees their field as changing and evolving, while noting the influence which technology has as well. Clearly this instructor views themself as a scientist but also has awareness of themself as an instructor. This instructor has a BARSTL score of 74, which implies a lecture oriented focus. However, this instructor is clearly comfortable with their role in their discipline and does not show any of the consternation of the previous response.

Question 34: Have you changed your teaching approach?

Question 34 of the questionnaire asked respondents if they had changed their approach in the classroom since they started teaching. The actual text of the question was as follows:

> Have you changed your approach in the classroom since you started teaching? Why?

There were three common responses to this question, and so these responses were coded for analysis. These responses were as follows:

1. Yes, I am incorporating new teaching practices (constructivist, etc.).
2. Yes, Technology has caused me to shift.
3. No Change.

Frequency data for these responses is given in Table 12.

Table 12

Frequency Data for Question 34: Have you changed your teaching approach?

		Frequency	Valid Percent
Valid	Yes, new practices	43	65.2
	Yes, technology	19	28.8
	No change	4	6.1
	Total	66	100.0
Missing	4	15	
Total		81	

Given the fast-changing nature of science education, it is not surprising that many instructors have changed their approach in the classroom. Community colleges work hard to expose instructors to new methods of teaching and new tools for the classroom, so it is also not surprising that so many instructors have adopted them into their classroom.

Quantitative analysis of coding. Analysis was performed to see if there was a significant relationship between change of teaching approach and overall BARSTL score. Here, the one-way between-subjects analysis of variance failed to reveal a major effect between the driving force behind a discipline on the overall BARSTL score, $F(2,63)=1.481$, $p=.235$, $\alpha = .05$. Figure 13 shows a means plot of change of teaching approach and overall BARSTL score.

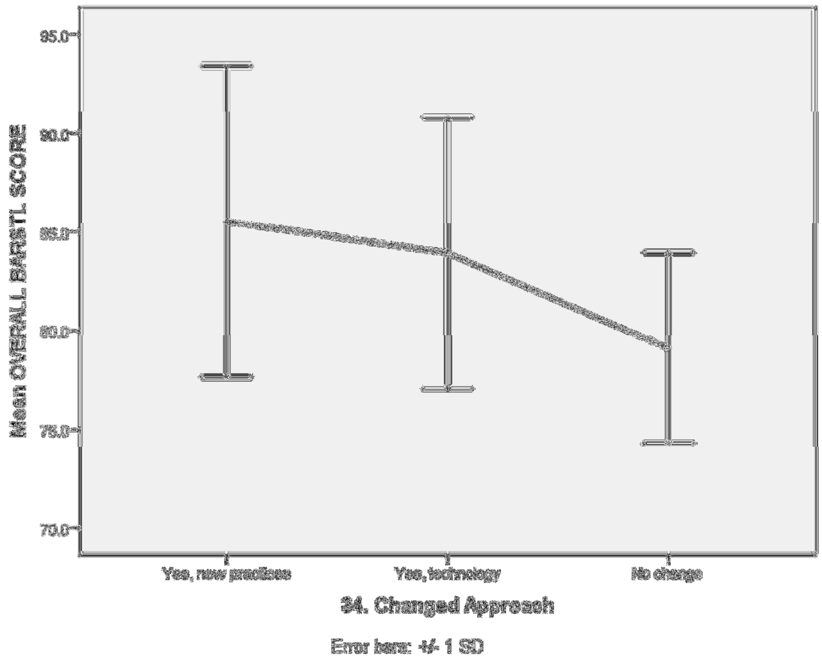

Figure 13. Means Plot of Question 34: Change in Teaching Approach and BARSTL score.

Of interest in Figure 13 is the comparatively low BARSTL score of instructors who have not changed their approach. It is quite possible, if there was a larger sample of instructors who had not changed their approach in the classroom, that this difference might have been significant. It is certainly worthy of further investigation.

Analysis was also performed to see if there was a significant relationship between change of teaching approach and BARSTL score components. Here the one-way multivariate analysis of variance failed to reveal a significant effect of between change of teaching approach on any of the components of the BARSTL score, $F(12, 240)=.981$, $p=.455$, Wilk's $\lambda=.875$, partial eta squared=.064, $\alpha=.05$.

Discussion. The most popular response to this question was (1) that instructors have adopted new teaching practices. Exploring these answers further reveals that the vast majority of those who have incorporated new teaching practices have shifted towards experiential learning. The two main reasons for this shift were to make the classroom fun/keep student's attention and to involve students in the learning process. A small minority of instructors noted that they had been forced to shift back towards lecture based instruction because of testing and mandatory coverage requirements as well. A very interesting response to this question was given by a physics/physical science instructor:

> Yes. When I first starting teaching (6 years ago), I tried to basically replicate the kind of classrooms I had experienced while in college. This meant the majority of time was spent with me lecturing or working example problems while the students just copied down what I said. . . . I attempted to switch entirely to an inquiry based model where students worked together and I gave them little direction up front. While this was better, I think that there were still problems. In theory, it sounded great to have students develop their own ideas through experimentation and discussion, but in practice, students were very easily distracted and many ended up learning very little this way because they did not fully participate. I have now settled on an approach that is a combination of these. . . .

This response shows the progression made by an instructor through their early years of teaching. This instructor started using a lecture focus and changed to try to help students understand the subject. They continued to refine their thinking about teaching after the initial change as well. It is interesting to note that, even though the instructor uses a mixed approach in the classroom, their BARSTL score is 105, which is highly student centered (80 is the average). Sometimes what an instructor believes is optimal and what they actually use can differ--here the instructor changed from a pure student centered approach in order to reach more students.

The next most popular response to the question was (2) that instructors have changed their teaching approach due to technology. Many teachers noted that changes in technology have allowed them to incorporate more experiential activities in the classroom and laboratories. In addition, some teachers were pleased that the improvement of calculators allowed them to focus on the "big picture." Other teachers lamented poor arithmetic skills they attributed to a rise in calculators. One instructor who was quite pleased with the introduction of technology in the classroom gave the following interesting response:

> Yes - in past the approach was much more "chalk and talk". Now, technology has allowed physics or engineering courses to be taught in a variety of ways with in-class assignments, labs, software applications, etc. The evolution is much better and will most likely never return to the former methods. A main change too is the adaptation to students where many do not wish to exercise discipline to learn a science or application because it takes too much time or effort. The lack of drive and dedication of some students is appalling.

Note here that a common lament throughout the free response answers given by instructors is a lack of motivation of students. One key reason to implement constructivist activities in the classroom is to engage and motivate students--it may not be that the students are unmotivated, just that they are not being reached by today's community college instructor. It is interesting that the use of technology in this particular instructor's classroom was unable to effectively engage students, despite the enthusiasm of the instructor. This instructor has an average BARSTL score of 84, so it is possible that the instructor is using constructivist tools without believing that they will work, resulting in the disconnection between belief and method described in Chapter 2.

By far the least popular response to the question was (3) that instructors have not changed their teaching approach at all. One instructor responded that they have not been teaching long enough to have a chance to change, which is quite understandable. The other responses were from experienced instructors who did not believe that they had changed or that they needed to change. A sample response of this type is below:

> Not really. I find that students today are woefully inadequately educated in science, so I have to give a lot of background, history and philosophy apart from strict facts. This has not changed.

Despite the negative connotation of the response, this instructor incorporates a diverse background into their lecture to keep students interested in the course. This approach has probably worked from the beginning of their teaching, so they have not changed it. This instructor's BARSTL score is 85, which is ever so slightly constructivist. It is quite possible that this instructor has changed since they started teaching and simply does not recognize it.

Question 35: What impact does your teaching style have on student learning?

Question 35 of the questionnaire asked respondents what impact they believed their teaching style had on student learning. This question was asked to directly assess the teachers' positivity and mindset in the classroom. The actual text of the question was as follows:

> Do you feel like your teaching style impacts how well your students learn in the classroom? How much of an impact do you think it has?

There were three common responses to this question, and so these responses were coded for analysis. These responses were as follows:

1. Yes, the determining factor
2. Yes, but only a little. Student is most important.
3. No impact

Frequency data for these responses is given in Table 13.

Table 13

Frequency Data for Question 35: What impact does your teaching style have?

		Frequency	Valid Percent
Valid	Yes, determining factor	53	81.5
	Yes, but student is most important	10	15.4
	No impact	2	3.1
	Total	65	100.0
Missing	4	16	
Total		81	

Teachers teach to make an impact in the classroom. It is one of the classical reasons people choose the profession. Moreover, it is logical to think that a teacher believes that the way they teach their subject is special and makes an impact--whether or not it is true. Only a few instructors believed that they had no impact on the success of students in their classroom, while a small minority of teachers believed that they had a minor impact on student success.

Quantitative analysis of coding. Analysis was performed to see if there was a significant relationship between teaching style impact and overall BARSTL score. Because the No Impact group was small, a t-test was conducted between the two Yes groups. Here, the t-test revealed an impact that was close to significant on the overall BARSTL score, $t(61) = 1.969$, $p = .054$. The results of this t-test are summarized in Table 14.

Table 14

T-test for Question 35: What impact does your teaching style have?

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
OVERALL BARSTL SCORE	Equal variances assumed	1.392	.243	1.969	61	.054	5.04

Table 14 (continued).

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
OVERALL BARSTL SCORE	Equal variances not assumed			2.370	15.517	.031	5.04

Figure 14 shows a means plot of teaching style impact and overall BARSTL score.

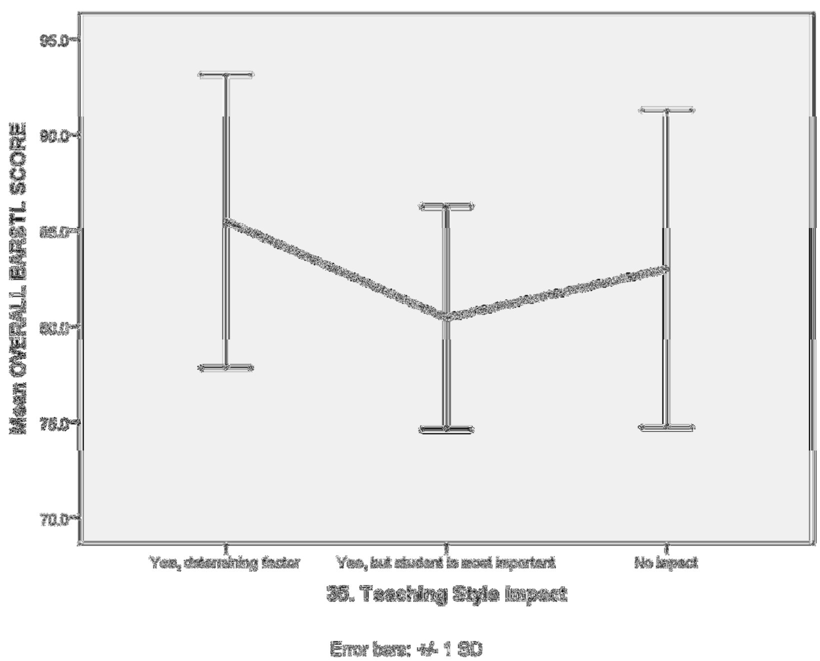

Figure 14. Means Plot of Question 35: Teaching Style Impact and BARSTL score.

As seen in Figure 14, there clearly appears to be a difference in BARSTL score between instructors who believe their teaching is most important to student success and instructors who believe that their teaching only contributes to student success. The t-test corroborates this difference, and clearly more investigation may be warranted. A MANOVA was not performed for this case because the group sizes are simply too uneven for an accurate result.

Discussion. By far, the most popular response to this question was (1) that the instructor's teaching in the classroom is the determining factor in student success. Teachers commonly replied that their teaching style works to help them engage with students, and that it is this engagement with the subject which improves student success. Other instructors commented that they are able to modify their teaching style to their class semester by semester, and that this personalization allows them to help their students. A typical response from an instructor answering (1) is below:

> Yes, I believe my approach to teaching greatly affects the students and their reception of the material. For example, if the material is presented in an interesting, informational way the students receive the information better than a formal, monotone lecture.

This instructor believes that student success and learning of material is directly related to how it is presented in the classroom. They make the material fun and exciting in the hope that students remember it. This instructor has a BARSTL score of 96, which is exceptionally constructivist. One can imagine that this classroom is structured in such a way as to allow students to fully engage with the subject, possibly including group projects and other ideas.

The second most common response to this question was (2) that the instructor's teaching in the classroom had an impact on student performance, but was not the determining factor. All of the instructors who answered this noted that it was not the instructor but the student who determined student success in the classroom. More specifically, some instructors believed that certain students would succeed, and others fail, regardless of the approach taken with them. Other instructors believed that all students had the potential for success if they worked outside of the classroom. An interesting response from an instructor is below:

> Some yes; some no. The "smart" kids are going to get it no matter what method or style the teacher uses. The "slow" ones and the ones who simply do not care aren't going to get it no matter what you do. It's that middle bunch that you try to reach. It is those who are impacted by a particular style of teaching.

This instructor believes that it is their role in the classroom to reach the 'borderline' children who have the potential to pass, but will not pass without assistance from the instructor--also known as 'teaching to the middle of the class.' This gives an instructor a group to focus on, and a group to tailor their lectures towards, hopefully with positive results. The instructor here has a BARSTL score of 76, which means that they are mildly lecture-oriented and not significantly constructivist.

Only a few instructors answered (3) that their teaching had no impact on the performance of their students. Every instructor who answered this believed that student work outside of the classroom was the single determinative factor in student performance. A representative response is below:

> No.. Learning is hardwork [sic]. Students learn by looking over an idea until they see the underlying reason or concept

This instructor believes that students control their own learning outcome and must study to achieve success. Interestingly, this instructor has a BARSTL score of 88, which would imply constructivist thinking. One has to wonder if they have not had success with their students in implementing constructivist ideas, and that is why they have taken such a pessimistic attitude toward the teacher's role in the classroom.

Question 36: Should all instructors in a department use a similar teaching style?

Question 36 asked instructors whether or not they believed all of the instructors in a department should use a similar teaching style. The exact wording of the question is below:

> Do you feel that all of the instructors in a department should use a similar teaching style? Why or why not?

Many departments have been moving towards a standardization of their lower level classes. At the University of Southern Mississippi, when they were taught in a lecture classroom, the College Algebra classes were standardized to a great degree (2004-06). This ensures that students receive the same type of teaching no matter the class. For example, the goal at Southern Miss was that students could go to a different instructor's class each week and still receive the same instruction. This question asked instructors if they thought standardization of teaching styles was a good thing. The response was overwhelmingly no. The most common responses are listed below:

1. No. Students and teachers should choose how to best learn
2. Yes. Standardization helps departments to improve
3. Unsure. Standardization is good for certain subjects.

Frequency data for these responses is given in Table 15.

Table 15

Frequency Data for Question 36: Should teaching styles be standardized?

		Frequency	Valid Percent
Valid	No, student and instructor choice is important	61	92.4
	Yes, standardization of classes	3	4.5
	Unsure, hard to balance concerns	2	3.0
	Total	66	100.0
Missing	4	15	
Total		81	

The overwhelming response against standardization of teaching styles was quite surprising. Teachers were very protective of their role in the classroom, and did not believe that it was in the student's best interest for all instructors to teach in the same manner. This result may imply that teachers would respond negatively to observing other teachers or learning about how they teach. At the very least, this result means that community college administrations must be very careful in how they approach the topic of standardization of teaching approaches.

Quantitative analysis of coding. The results here were overwhelmingly in favor of no standardization, and did not meet the minimum requirements for an ANOVA or a MANOVA. Still, clearly there is a strong result here--community college instructors do not want to have their instruction standardized. For completeness, Figure 15 gives a means plot between standardization and overall BARSTL score.

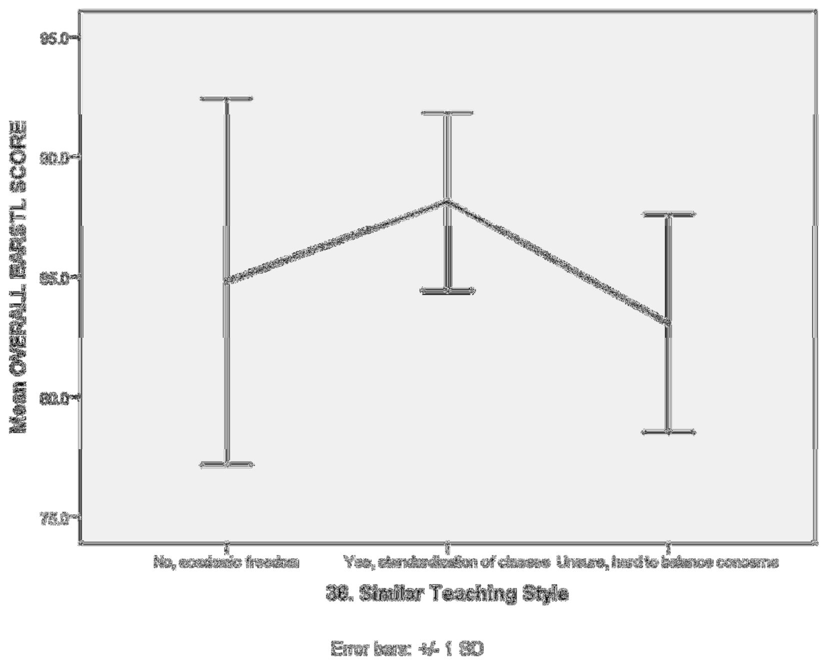

Figure 15. Means Plot of Question 36: Teaching Style Impact and BARSTL Score.

While those instructors in favor of standardization had a higher BARSTL score than those not in favor of standardization, clearly there were simply not enough Yes responses to say that this result is significant. It may be worthy of further investigation; however, the overwhelming number of community college instructors against standardization may make this difficult.

Discussion. The single most popular response on this entire survey was (1) instructors should not use a similar teaching style throughout their department. The vast majority of the instructors answering this believed that instructors should teach in the manner they are best suited, and students should choose the instructor that best fits them. These instructors believed that standardization would hurt students' performance by forcing them to attend a particular style of class.

A few instructors went further with this argument, making a forceful case that standardization harms diversity in the department and prevents teachers from reaching all of their students. These instructors believed that standardization removes their ability to adapt to unique classroom conditions, which change from semester to semester. In addition, some teachers noted that having department wide objectives and goals was not harmful, as long as the instructors were allowed to meet them in a manner of their own choosing. There were two particularly eloquent responses to this question that deserve further investigation. First:

> I think instructors should do what they individually do best. There are different methods of instruction, just as there are different ways to learn. But each instructor should be a bit fluid in his/her approach. Not every problem is a nail needing a hammer.

This instructor believes that each teacher should teach in the manner which they are best suited, and that this will help overall student performance. However, they stress the need for flexibility as well. The instructor here has a BARSTL score of 85, which is slightly student centered. As an aside one might think that student centered instructors would want more control over their classroom structure, to be able to implement creative ideas and group activities (see Smith & Southerland, 2007 for an example).

Another insightful response is as follows:

> No, students have different learning styles and if the department used a style that is not compatible with a student's learning style they may be discouraged from pursuing further coursework in a particular field. Also, interacting with different personalities prepares students for the workforce.

This instructor makes the point that if a student feels uncomfortable with the approach taken in a classroom, they may try a different class. If that approach is taken in *every* classroom, then that student may simply give up. Community colleges must reach a wide variety of students, so the premise of this argument is clear. This instructor has a BARSTL score of 82, which is in the center (not constructivist or lecture oriented).

A few instructors argued (2) that standardization of teaching approaches was a positive development. These instructors made the arguments generally seen from administrators. Instructors should use the best, most effective teaching style. In addition, they argued that it is difficult to improve a department if everyone is using a different approach. This feels like it is the strongest argument made by this group. A representative response from this group is the following:

> Yes. Continuous improvement isn't possible for a program if everyone does something different.

This is clearly the argument described above. This instructor believes that just because a teaching approach is currently effective, this does not mean that it will continue to be effective. To improve a department, the instructors must start from the same or similar points. This instructor has a BARSTL score of 86, which is constructivist. This likely means that the starting point the instructor wants for their department is a constructivist approach.

The final response, given only by two instructors, was that they were unsure if the same approach should be used by all instructors. Both of these instructors primarily taught laboratory classes, and they believed that standardization of the approach in the lab portion of the class was a good and necessary idea. However, they did not know if standardization would be appropriate in the lecture portion.

Summary of Findings

An independent sample t-test was conducted to investigate whether the groups created by the answers to the demographic and short answer questions met the assumption of homogeneity of variance with respect to the overall BARSTL score. The assumption of homogeneity of variance was met for all questions except Questions 37 and 38. Questions 35 and 36 were not investigated by an ANOVA and so their results are not listed in this table, though their means are given. Table 16 summarizes these results.

Table 16

Levene's Test for Homogeneity of Variance

Question	Category	N	BARSTL mean	t
33. What is the driving force which causes your discipline to change?	Driven by Politics	28	85.5	*p*=.694
	Driven by Technology	13	84.8	
	Driven by Discoveries	16	83.7	

Table 16 (continued).

Question	Category	N	BARSTL mean	t
34. Have you changed your approach since you started teaching?	Yes, new practices	43	85.5	*p*=.504
	Yes, technology	19	83.9	
	No change	4	79.1	
35. How much impact does your teaching style have on student learning?	Yes, determining factor	53	85.5	---
	Yes, but student is most important	10	80.4	
	No impact	2	83.0	
36. Should a department use similar teaching styles?	No, academic freedom	61	84.8	---
	Yes, standardization of classes	3	88.1	
	Unsure, hard to balance concerns	2	83.1	
37. Hours Taught per Week	1-9	7	80.7	*p*=.021
	10-15	16	83.7	
	16+ hours	57	85.1	
38. Years of Teaching Experience	0-5 years	12	86.0	*p*=.042
	6-10 years	14	86.8	
	11-15 years	19	86.2	
	16+ years	36	82.1	

Table 16 (continued).

Question	Category	N	BARSTL mean	t
39. Age of Instructor	21-35 years	19	88.5	*p*=.336
	36-49 years	23	85.0	
	50-64 years	34	82.3	
	65+ years	5	80.4	
40. Field of Instructor	Biology	29	84.4	*p*=.210
	Chemistry	7	82.9	
	Computer Science	5	81.7	
	Mathematics/statistics	27	84.1	
	Physics/physical science	11	88.8	
41. State of Residence of Instructor	Alabama	10	83.3	*p*=.648
	Louisiana	12	85.9	
	Mississippi	40	84.6	
	Tennessee	18	83.9	
42. Birth Order	Only child	7	82.5	*p*=.174
	Youngest child	25	85.1	
	Middle child	12	82.6	
	Oldest child	36	85.2	

An ANOVA was conducted to examine the significance of the differences in overall BARSTL score between the categories of the two short answer questions 33 and 34 and all of the demographic questions 37 through 42. These ANOVAs found no significant difference between the groups except in one case, Age. The ANOVA for Question 39 found a significant difference in overall BARSTL score based on Age category. Specifically, post hoc tests found a significant difference between the 21-25 age group and the 50-64 age group. The results of these post hoc tests are given in Table 9. The results of the t-test that was performed on Question 35 can be found in Table 9. The ANOVA results are summarized in Table 17.

Table 17

ANOVA Results for Questions 33, 34, 37-42

Question		df	F	Sig.
33. What is the driving force which	Between Groups	2	.343	.711
causes your discipline to change?	Within Groups	63		
34. Have you changed your approach	Between Groups	2	1.481	.235
since you started teaching?	Within Groups	63		
37. Hours Taught per week	Between Groups	2	1.222	.300
	Within Groups	77		
38. Years of Teaching Experience	Between Groups	3	2.425	.072
	Within Groups	77		
39. Age of Instructor	21-35 years	3	3.861	.013
	36-49 years	77		

Table 17 (continued).

Question		df	F	Sig.
40. Field of Instructor	Between Groups	4	1.239	.302
	Within Groups	74		
41. State of Residence of Instructor	Between Groups	3	.269	.848
	Within Groups	76		
42. Birth Order	Between Groups	3	.590	.623
	Within Groups	76		

A MANOVA was also conducted on Questions 33, 34, and 37-42 to examine the significance of the differences in BARSTL subscores between the categories in the short answer questions and demographic questions. As part of these tests, Box's Test of Equality of Covariance Matrices was also calculated to ensure that the MANOVAs would be valid. In all cases, Box's M was not significant, indicating that the observed covariance matrices of the BARSTL subscores are equal across the groups. No significant difference between groups was found in any of the MANOVAs that were conducted. The results of these MANOVAs are summarized in Table 18.

Table 18

MANOVA Results for Questions 33, 34, 37-42

	Box's Test of Equality of Covariance Matrices		Multivariate Tests of MANOVA (Wilk's Lambda only)			
Question	Box's M	Sig. of Box's M	Value of Wilk's Lambda	F	Sig.	Partial Eta Squared
33. What is the driving force which causes your discipline to change?	21.799	.527	.805	1.378	.216	.103
34. Have you changed your approach since you started teaching?	16.271	.141	.875	.981	.455	.064
37. Hours Taught per week	19.486	.727	.953	.432	.900	.024
38. Years of Teaching Experience	49.603	.056	.863	.898	.550	.048
39. Age of Instructor	41.345	.350	.830	1.146	.325	.060

Table 18 (continued).

	Box's Test of Equality of Covariance Matrices		Multivariate Tests of MANOVA (Wilk's Lambda only)			
Question	Box's M	Sig. of Box's M	Value of Wilk's Lambda	F	Sig.	Partial Eta Squared
40. Field of Instructor	42.059	.824	.830	.819	.663	.046
41. State of Residence of Instructor	35.782	.443	.809	1.286	.229	.068
42. Birth Order	44.004	.194	.878	.780	.670	.043

Results of Research Question 1

Where does the average community college science instructor in the Southeastern United States lie on the BARSTL continuum? Do they have a traditional discipline-focused approach, or do they have a constructivist student-centered approach?

As shown in Table 3, the average community college instructor has a score of 84.4 on the BARSTL continuum. For point of reference, a perfectly balanced instructor would have a score of 80 on the BARSTL continuum. A perfectly lecture focused (teacher focused approach) instructor would have a score of 32, and a wholly constructivist (student focused approach) instructor would have a score of 128. This places the average community college instructor squarely in the middle of the continuum, taking a balanced approach with a slight tilt towards constructivism. The BARSTL scores of instructors range quite widely, with a lower bound of 70 and an upper bound of 105. Note that this means that there are some community college instructors who are quite constructivist.

Results of Research Question 2

Where is the average instructor placed in the individual BARSTL categories: how people learn about science, lesson design and implementation, characteristics of teachers and the environment, and the nature of the science curriculum?

As shown in Table 4, the BARSTL subscores have a mean of 20.6, 20.9, 21.4, and 21.23 for the categories of how people learn about science, lesson design and implementation, characteristics of teachers and the learning environment, and the nature of the science curriculum, respectively. These BARSTL subscores have a possible range from 8 to 32--8 meaning wholly lecture-focused, 32 meaning entirely constructivist, and a score of 20 indicating a balanced view of the two approaches. This means that, on the whole, community college instructors lie in the center of each of the categories represented by the BARSTL. They took a fully balanced approach towards how people learn about science and lesson design and implementation, with a slightly more constructivist attitude toward characteristics of teachers and the learning environment and the nature of the science curriculum.

BARSTL subscores I-III had a wide range in their responses, ranging from 15-16 to 27-29. This indicates that instructors may have a constructivist or a lecture oriented view of individual categories. BARSTL subscore IV had a much smaller range, only from 18 to 24, indicating a much more balanced view of the nature of the science curriculum. This is an interesting result, and may have occurred because instructors were looking at "science" as a whole rather than their individual subject, causing them to be more objective in their assessment of the science curriculum.

Results of Research Question 3

Is there a significant relationship between teaching philosophy (BARSTL score) and the number of hours an instructor teaches in a semester? Is there a significant difference between BARSTL components and the number of hours an instructor teaches in a semester?

Statistical analysis was conducted to answer this question. Here, the one-way between-subjects analysis of variance failed to reveal a major effect of hours taught in the classroom on the overall BARSTL score, $F(2,77)=1.222$, $p=.300$, $\alpha = .05$. In addition, the one-way multivariate analysis of variance failed to reveal a major effect of hours taught in the classroom on any of the components of the BARSTL score, $F(8, 296)=.432$, $p=.900$, Wilk's $\lambda=.953$, partial eta squared=.024, $\alpha = .05$. This research shows no significant relationship between teaching philosophy and BARSTL score or BARSTL components.

Results of Research Question 4

Is there a significant relationship between teaching philosophy (BARSTL score) and years of teaching experience? Is there a significant difference between BARSTL components and years of teaching experience?

Statistical analysis was also conducted to answer this question. The one-way between-subjects analysis of variance failed to reveal a major effect of years of teaching experience on the overall BARSTL score of the respondents, $F(3,77)=2.425$, $p=.072$,

$\alpha = .05$. In addition, one-way multivariate analysis of variance failed to reveal a major effect of years of teaching experience on any of the components of the BARSTL score, $F(8, 296)=.898$, $p=.550$, Wilk's $\lambda=.863$, partial eta squared=.048, $\alpha = .05$. This research shows no significant relationship between years of teaching experience and BARSTL score or BARSTL components.

Results of Research Question 5

Is there a significant relationship between teaching philosophy (BARSTL score) and age of the instructor? Is there a significant difference between BARSTL components and age of the instructor?

Statistical analysis for this question produced interesting results. Here, the one-way between-subjects analysis of variance revealed a significant effect of age on the overall BARSTL score, $F(3,77)=3.861$, $p=.013$, $\alpha = .05$. These results can be seen in Table 8. Tukey post hoc tests showed that there is a significant difference between the 21-35 age group and the 50-64 age group. 21-35 year olds are markedly more constructivist than their 50-64 year old counterparts. This makes sense--instructors teach in the manner in which they are taught. The relationship between age and BARSTL score may be linear, as shown in Figure 8, but more research needs to be done to examine it.

Statistical analysis of the subscores did not show a similar significant relationship. The one-way multivariate analysis of variance failed to reveal a significant effect of age of the respondent on any of the components of the BARSTL score, $F(8, 300)=1.146$, $p=.325$, Wilk's $\lambda=.830$, partial eta squared=.060, $\alpha = .05$. Essentially, this means that there is a significant relationship between age and overall BARSTL score, but age does not impact any particular BARSTL subscore in a significant manner.

Results of Research Question 6

Is there a significant relationship between teaching philosophy (BARSTL score) and the specific science which is primarily taught by an instructor? Is there a significant difference between BARSTL components and the specific science which is primarily taught by an instructor?

Statistical analysis was conducted to answer this question. Here, the one-way between-subjects analysis of variance failed to reveal a major effect of STEM field taught by an instructor on the overall BARSTL score, $F(4,74)=1.239$, $p=.302$, $\alpha = .05$. In addition, the one-way multivariate analysis of variance failed to reveal a significant effect of the STEM field taught by an instructor on any of the components of the BARSTL score, $F(16, 284)=.819$, $p=.663$, Wilk's $\lambda=.830$, partial eta squared=.046, $\alpha = .05$. This research shows no significant relationship between the science taught by an instructor and BARSTL score or BARSTL subcomponents.

Results of Research Question 7

Is there a significant relationship between teaching philosophy (BARSTL score) and the state in which an instructor teaches? Is there a significant difference between BARSTL components and the state in which an instructor teaches?

Statistical analysis was used to answer this question. The one-way between-subjects analysis of variance failed to reveal a major effect between state of residence on the overall BARSTL score, $F(3,76)=.269$, $p=.848$, $\alpha = .05$. Also, the one-way multivariate analysis of variance failed to reveal a significant effect of state of residence on any of the components of the BARSTL score, *F*(12, 292)=1.286, *p*=.229, Wilk's λ =.809, partial eta squared=.068, $\alpha = .05$. This research shows no significant relationship between the state in which an instructor teaches and BARSTL score or BARSTL subcomponents.

Results of Research Question 8

Is there a significant relationship between teaching philosophy (BARSTL score) and birth order of the instructor? Is there a significant difference between BARSTL components and birth order of the instructor?

Statistical analysis was used to answer this question. For question 8, the one-way between-subjects analysis of variance failed to reveal a major effect between birth order on the overall BARSTL score, *F*(3,76)=.590, *p*=.623, $\alpha = .05$. Also, the one-way multivariate analysis of variance failed to reveal a significant effect of birth order on any of the components of the BARSTL score, *F*(12, 292)=.780, *p*=.670, Wilk's λ=.878, partial eta squared=.043, $\alpha = .05$. This research shows no significant relationship between birth order of the instructor and BARSTL score or BARSTL subcomponents.

Results of Research Question 9

What do community college science instructors believe is the driving force behind making their discipline change? Is it driven by discoveries within the discipline? Is it driven by outside forces, such as politics?

This question was answered through coding methods as well as quantitative analysis. The most common responses were: my discipline is primarily driven by politics and political forces, my discipline is primarily driven by technology, and my discipline is primarily driven by discoveries and change from within. By far the most popular answer was that instructors believed politics and political forces drove change in their discipline, both through outside regulation as well as the administration of research money. Some instructors believed that changes in technology were changing their discipline in both positive and negative ways--positive in allowing more complex ideas to be shown to students, negative in that students were unable to perform arithmetic they once were able to do. In addition, some instructors believed that discoveries within their discipline are what cause it to change--these instructors generally took a holistic view of their field and believed it to be evolving through research. This research shows that though most instructors believe politics is the driving force of change in their discipline, many other instructors hold differing views.

Statistical analysis was also used to see if these answers had a significant relationship to BARSTL score or BARSTL subscore. Here, the one-way between-subjects analysis of variance failed to reveal a major effect between the driving force behind a discipline and the overall BARSTL score, $F(2,54)=.234$, $p=.792$, $\alpha = .05$. In addition, the one-way multivariate analysis of variance failed to reveal a significant effect of the driving force behind a discipline on any of the components of the BARSTL score, $F(12, 204)=1.378$, $p=.216$, Wilk's $\lambda=.805$, partial eta squared=.103, $\alpha = .05$. This research shows no significant relationship between the answers given for driving force behind an instructor's discipline and BARSTL score or BARSTL subcomponents.

Results of Research Question 10

Do community college instructors change their approach in the classroom after they begin teaching?

This question was answered through coding methods as well as quantitative analysis. The three most popular answers were: yes, the instructor has changed to incorporate new teaching practices; yes, the instructor has changed to incorporate new technology; and no, the instructor has not changed their approach in the classroom. The most common response was that instructors had changed their approach to accommodate new teaching practices. Of note is the finding that virtually all community college instructors surveyed have changed their approach since they started teaching--only four had not. Those instructors generally believed that there was no reason for them to alter their approach. This research shows that most teachers do indeed change their approach in the classroom after they start teaching, and they change in order to accommodate new teaching methods which they have gained.

Statistical analysis was also used to see if there was a significant relationship between the most common responses to question 10 and BARSTL score or BARSTL subcomponents. Here, the one-way between-subjects analysis of variance failed to reveal a major effect between the driving force behind a discipline and the overall BARSTL score, $F(2,63)=1.481$, $p=.235$, $\alpha = .05$. The one-way multivariate analysis of variance failed to reveal a significant effect of change of teaching approach on any of the components of the BARSTL score, $F(12, 240)=.981$, $p=.455$, Wilk's $\lambda=.875$, partial eta squared=.064, $\alpha = .05$. This research shows no significant relationship between the most common answers to research question 10 and BARSTL score or BARSTL subscores.

Results of Research Question 11

Do community college instructors believe their teaching style impacts how well their students learn in the classroom?

This question was answered through coding methods as well as quantitative analysis. The most common responses were: yes, the instructor believes teaching style is the determining factor in student performance; yes, the instructor believes teaching style has a small impact on student performance; and no, the instructor believes student performance is entirely based on the efforts or ability of the student. The majority of instructors believed that their teaching style determined student performance in their classroom. Only two instructors believed that their teaching style was not important in the performance of students--these instructors believed that student success or failure is determined by their work outside of the classroom only. This research shows that the majority of instructors believe that their teaching style is the determining factor in how well a student performs in the classroom.

Statistical analysis was used to see if there was a statistical relationship between the two yes responses to question 11. Here, the t-test revealed an impact that was close to significant on the overall BARSTL score, $t(61) = 1.969$, $p = .054$. Teachers who believed that their teaching was most important have a higher overall BARSTL score than teachers who believed their teaching has only a small impact, and this relationship may be significant. This research shows no significant relationship between whether an instructor believes their teaching style is the determining factor in student performance, but the result is close enough that more research may need to be done to investigate.

Results of Research Question 12

Do community college instructors believe that all of the instructors in a department should use a similar teaching style?

This question was answered through coding methods. The most common answers were: no, students and teachers should choose how to best learn; yes, standardization helps departments to improve, and unsure, standardization is good for certain subjects. The vast majority of instructors were against standardization of teaching style, and most of them were quite vocal in their opposition. The most common arguments made were that teachers need to be able to adapt their teaching to individual students and students should be able to have a choice of teachers who teach different styles. A few instructors believed that standardization was useful in certain classes--mainly laboratory classes where there may be an optimal approach to topics. A few instructors also believed that standardization was important, to help departments improve themselves. Clearly though, this research shows that most instructors do not believe that all instructors should use a similar teaching style.

Summary

This study used frequency and descriptive statistics, t-tests, analysis of variance statistics, and multivariate analysis of variance statistics to answer the research questions posed. Data on teaching beliefs was collected from community college science instructors from Alabama, Louisiana, Mississippi, and Tennessee. This data was collected using a modified form of the Beliefs About Reformed Science Teaching and Learning (BARSTL) questionnaire, developed by Sampson and colleagues (2013). The first two research questions posed asked where the average community college science instructor lay on the BARSTL continuum of teaching beliefs. The next six research questions sought to find a significant relationship between BARSTL score and hours spent teaching in the classroom, years spent teaching, age of instructor, science taught, state in which instructor was teaching, and birth order of the instructor. Finally, the last four research questions sought to examine the positions of instructors on where their teaching beliefs come from, how they are performing, and if they would be willing to change. An independent sample t-test was conducted to investigate whether the groups created by the answers to the demographic and short answer questions met the assumption of homogeneity of variance with respect to the overall BARSTL score. The assumption of homogeneity of variance was met for all questions tested except Questions 37 and 38.

This study found that community college science instructors have a generally balanced view of teaching (average score of 84, where 80 is a balanced view), believing that both lecture and constructivist activities have a place in the classroom. This was true of the score of the BARSTL components as well (average scores of 20 and 21, where 20 represents a balanced view). In addition, using an ANOVA, this study also found a significant relationship between age and teaching beliefs (p=.013)--post hoc tests showed that teachers who are younger tend to have more constructivist views on teaching, while older teachers tend to be more lecture focused.. This significant relationship did not carry over into the BARSTL components--a MANOVA showed that no component score was significantly impacted by age. Further, additional ANOVAs and MANOVAs showed that no other demographic key had a significant impact on BARSTL score or BARSTL subscore.

The short answer questions gave much insight into the thinking of community college science instructors. This study found that 41% of instructors surveyed believe that politics and political thinking are the most dominant influence on their disciplines.

Most instructors surveyed (65%) have modified their teaching since the beginning of their career to incorporate new techniques learned while an instructor. In addition, a clear majority of instructors surveyed (81%) believe that their teaching is the determining factor in how well students perform in their classroom. Finally, 92% of community college science instructors surveyed emphatically do not want their department to use a similar teaching style--they believe that students and faculty should be free to choose the approach that works best for them. Most of these beliefs were not found using ANOVAs and MANOVAs to have a significant relationship with BARSTL score or subscore respectively--these opinions were held by all instructors no matter their teaching beliefs. However, the difference in overall BARSTL score between science instructors who believed that their department should use a similar teaching style and should not use a similar teaching style was found by a t-test to be almost significant ($p=.054$), and this may merit further investigation. Teachers who favored a similar teaching style had a substantially more constructivist viewpoint than those who did not. These results indicate that community college science instructors are able and willing to change and incorporate new approaches to teaching, but that they may be resistant to efforts to standardize their approach.

CHAPTER V

DISCUSSION

Summary of Study

It was the purpose of this study to examine the teaching beliefs of community college science instructors and discover if they were student oriented or instructor oriented. In addition, this study sought to examine demographic factors and find their relation, if any, to these teaching beliefs, as well as explore topics that may be useful in the future to helping community colleges science instructors' curricula and beliefs come together and work in unison. To do this, this study built on the foundation laid by Sampson et al. in their creation of the Beliefs about Reformed Science Teaching and Learning (BARSTL) questionnaire. This study consisted of the BARSTL framework, together with six demographic questions and four short answer questions. Quantitative and qualitative methods were used to analyze the significance of the differences between the BARSTL score and the demographic groups created by the questions.

Several factors were quantitatively analyzed in this study. First, the overall BARSTL score, representing an instructor's placement on the continuum of teaching belief, as well as their four BARSTL subscores, representing that instructor's placement in the four subcategories that make up the BARSTL were calculated using the method set out by Sampson et al. (2013). Coding methods were used to find the most common responses given for the short answer questions. Next, descriptive statistics, means analysis, and graphing tools were used to examine the overall BARSTL score and BARSTL subscores and the groups created by the ten follow up questions.

Mean BARSTL scores and subscores for all 36 groups created by the follow up questions were calculated. Homogeneity of variance between the groups created by the nine questions was calculated where the group size was sufficient to meet statistical requirements (one question had a single, overwhelming, common response). Eight ANOVAs were then used, along with post hoc tests where appropriate, to see if there was a significant difference between the BARSTL scores in the groups created by eight questions. Additionally, eight MANOVAs were used, along with post hoc tests where appropriate, to examine whether there was a significant difference between the BARSTL subscores in the groups created by the eight questions. Further, one question lent itself to a t-test to examine the difference in the groups created by the two most common responses, and it was performed as well. Further, certain responses to the four short answer questions were explored using qualitative means to further understand why community college science instructors responded in the manner in which they did, and what implications their responses may have for community colleges and science beliefs.

Description of Sample

Community college science instructors from Alabama, Louisiana, Mississippi, and Tennessee who responded to a targeted email comprised the sample used for this study. The study included 78 participants (N=78). Participants came from every state, with 10 each coming from Alabama and Louisiana (12.8%), 18 from Tennessee (23.1%), and 39 coming from Mississippi (50%). In addition, 29 participants taught Biology (37.2%), 7 taught Chemistry (9%), 31 taught Mathematics or Computer Science (39.7%), and 9 taught Physics or Physical Science (11.5%).

Description of Study Variables

The variables in this study were comprised of the results of the Modified BARSTL (Appendix A) that was administered to the community college science instructors. The principal set of variables were the BARSTL score itself and the BARSTL subscores, calculated from questions 1-32 using the scoring method developed by Sampson et al. (2013) and described in Chapter IV. In addition, the results of the demographic questions 37-42 were used in analyzing the results of the BARSTL and examining relationships between the BARSTL score and other factors. Finally, the results of the short answer questions 33-36 were coded and provided additional variables for analysis.

Analysis of Research Questions

This paper sought to investigate the teaching beliefs of community college science instructors in a three step process. First, it asked where the average community college science instructor would lie on the BARSTL scale of teaching beliefs. The data indicated that community college science instructors generally lie in the middle of the continuum, having beliefs which are both lecture focused as well as student focused. This paper then asked if there is a way to predict where an instructor might lie on the BARSTL continuum from demographic indicators. The data indicated that age, alone, among the demographic keys examined, had a significant impact on BARSTL score. Younger teachers tended to be more student focused, while older teachers were more balanced in their approach.

And finally, this paper explored if there were any indicators that community college science instructors are willing to change their teaching approach, and, if so, how and why? The data indicated that community college instructors are willing to change the approach they use in the classroom, but they are very wary of outside intervention in the classroom. Not only are they unwilling to use the same approach as their colleagues, but they also mentioned politics and the influence of politics on their discipline as the most important factor shaping science education today. Clearly, care must be taken when working with community college science instructors and addressing their work in the classroom.

Research Question One

Research question one asked: Where does the average community college science instructor in the Southeastern United States lie on the BARSTL continuum? Do they have a traditional discipline-focused approach, or do they have a constructivist student-centered approach?

The average community college science instructor has a BARSTL score of 84.4 on a range of 32 to 128, as shown in Table 3. This score places them slightly student-centered, just slightly off the mean. The BARSTL score of community college science instructors ranges from 70 to 105, with a standard deviation of 7.3, as also shown in Table 3. This means that, even though the average community college science instructor has teaching beliefs balanced between a student-centered and teacher-centered approach, there is much variation around this central point. However, no science instructor came close to the extremes, meaning that every instructor had a somewhat balanced view. This means that community college science instructors should be compatible with any curriculum which also takes a generally balanced approach, using both lecture based and student centered approaches.

This is reinforced in the responses to the short answer question where the survey asked if any instructor had modified their lesson plans since they had begun teaching. Specifically, some teachers who began with a constructivist view noted they felt it necessary to include more lectures to cover required objectives. In addition, instructors who began with a more traditional lecture-based approach noted that they had heavily modified their teaching based on individual classes and to include more student involvement. In both cases, it can be seen that the instructors are moving toward a centrist belief structure, including elements of both student and teacher centered belief systems.

Research Question Two

Research question two asked: Where is the average instructor placed in the individual BARSTL categories: how people learn about science, lesson design and implementation, characteristics of teachers and the environment, and the nature of the science curriculum?

The average community college science instructor has a score of between 20 and 21, on a scale of 8 to 32, in each of these four categories, as seen in Table 4. This places them at the center of each of the subscales as well, meaning that community college science instructors have a balanced view of each of these categories. Three of the four categories: how people learn about science, lesson design and implementation, and characteristics of teachers and the environment had a standard deviation of 2.6 with a wide range of 11 to 29, as seen in Table 4. The fourth category, the nature of the science curriculum, had a much smaller standard deviation of 1.4, with a range of 18 to 24. This means that, while community college science instructors vary widely in their view of the first three categories, they are in general agreement on the fourth, the nature of the science curriculum.

Generally, the differences in BARSTL scores between the instructors were created by high or low scores in one or two of the first three categories, with scores close to the mean in the other categories. Each of these first three categories had instructors who took a lecture-based view as well as a student-centered view. This means that even instructors with the same or similar BARSTL scores have a different point of view, since they may have arrived at a balanced approach in a different manner. Again, this is reinforced in the answers to the short answer questions discussed under Research Question One. Instructors who began their teaching from a constructivist or a lecture oriented approach discuss modifying their approaches to better reach students. These modifications are typically inclusions of elements from the opposite point of view--a lecture oriented instructor involves their students with group or other activities, and a constructivist instructor includes more lectures and teacher oriented activities. This may explain why the overall BARSTL score as well as the BARSTL subscores demonstrate a balanced teaching belief structure.

Research Question Three

Research question three asked: Is there a significant relationship between teaching philosophy (BARSTL score) and the number of hours an instructor teaches in a semester? Is there a significant difference between BARSTL components and the number of hours an instructor teaches in a semester?

BARSTL score and the number of hours an instructor teaches in a semester were analyzed using a one-way univariate analysis of variance to see if there was a significant relationship between them. Statistical analysis showed no significant relationship between BARSTL score and the number of hours an instructor taught in a semester. This question investigated whether part time instructors had a different teaching belief system than full time instructors. The data showed that the more hours an instructor taught, the higher their overall BARSTL score, and so the more student-centered the instructor's belief system, though this relationship was not statistically significant. The difference between the average BARSTL score of instructors who taught nine hours or less a week and instructors who taught more than nine hours was comparatively large, however (+3), and may warrant further investigation. It may be that the more time an instructor spends in a classroom around their students, the more student centered their thinking (which is what the raw data may indicate), but this simply is not yet supported by statistical results.

The BARSTL component scores and the number of hours an instructor teaches in a semester were analyzed using a one-way multivariate analysis of variance to see if there was a significant relationship between them. Statistical analysis showed no significant relationship between any of the BARSTL component scores and the number of hours an instructor taught in a semester. If a significant relationship had been found between hours taught in a semester and overall BARSTL score, this analysis might have yielded some useful insight into the relationship. However, this analysis was worth performing because a significant relationship might have existed between one of the BARSTL components and the number of hours an instructor taught, which was not reflected in the relationship between overall BARSTL score and hours taught.

Research Question Four

Research question four asked: Is there a significant relationship between teaching philosophy (BARSTL score) and years of teaching experience? Is there a significant difference between BARSTL components and years of teaching experience?

BARSTL score and years of teaching experience of an instructor were analyzed using a one-way univariate analysis of variance to see if there was a significant relationship between them. Statistical analysis showed no significant relationship between years of teaching experience and overall BARSTL score. Because community college instructors come from many varied backgrounds, it was decided for this study to examine both years of teaching experience as well as age of an instructor to see if either factor impacted teaching beliefs. It is worth noting that, though a significant relationship was not found between the years of teaching experience and overall BARSTL score, the data still indicated that there might be something worth investigating here ($p=.072$). In addition, the average BARSTL means for the different years of teaching experience started at a centrist group for the new instructors, quickly became student focused as instructors gained experience, but then gradually returned to the center as teachers gained even more experience. This harmonizes well with answers given to the short answer questions as well as the results of research question five.

The BARSTL component scores and years of teaching experience of an instructor were analyzed using a one-way multivariate analysis of variance to see if there was a significant relationship between them. Statistical analysis showed no significant relationship between any of the BARSTL component scores and years of teaching experience of an instructor. As in the question above, this analysis serves to eliminate potential factors which might influence the BARSTL score components.

Research Question Five

Research question five asked: Is there a significant relationship between teaching philosophy (BARSTL score) and age of the instructor? Is there a significant difference between BARSTL components and age of the instructor?

The overall BARSTL score and the age of responding instructors were analyzed using a one-way univariate analysis of variance to see if there was a significant relationship between them. Statistical analysis showed that there was a significant relationship between age and overall BARSTL score. Post hoc tests showed that there was a significant difference between the BARSTL scores of the 21-35 year age group and the 50-64 year age group. In general, as an instructor ages, their BARSTL score becomes more balanced, starting very student focused when they are young, and returning to a more balanced approach as they age. This is supported by evidence given in responses to the short answer questions, where instructors talk about modification of their initial teaching styles so that they can cover objectives and other ideas. However, this is not the only possible explanation of the observed shift back towards the center.

It is possible that these instructors have not changed much in their teaching philosophy, even though they personally believe that they have--as shown in responses to research question ten. In this case, the younger instructors may naturally be more student focused because that is simply the way they were educated in school. Older instructors may be more balanced in their teaching beliefs because that is how they were educated in school. Further investigation is necessary to see if a single community college science instructor has an ever-changing teaching philosophy, or if they begin at a certain point and only deviate slightly from that point. If community college science instructors are constantly changing their teaching philosophy, it should be possible to channel that change in a direction which is beneficial to the institution and harmonized with their science curriculum. More on this idea will be covered under implications for policy and practice.

BARSTL component scores were also analyzed using a one-way multivariate analysis of variance to see if there was a significant relationship between any of the component scores and age of the instructor. Statistical analysis failed to find a significant relationship between any of the component scores and age of the instructor. This means that even though there is a significant relationship between the overall BARSTL score and age of the instructor, no single BARSTL component score is the driving force of this relationship. Synergy between the BARSTL component scores creates the relationship, which means that it is important to examine every BARSTL component when addressing the teaching beliefs of a community college science instructor.

Research Question Six

Research question six asked: Is there a significant relationship between teaching philosophy (BARSTL score) and the specific science which is primarily taught by an instructor? Is there a significant difference between BARSTL components and the specific science which is primarily taught by an instructor?

Overall BARSTL score and the science taught by an instructor were analyzed using a one-way univariate analysis of variance to see if there was a significant relationship between them. No significant relationship was found between overall

BARSTL score and the science taught by an instructor. Computer science instructors were found to have the most balanced teaching beliefs, while physics instructors were found to have the most student centered teaching beliefs, though these relationships were not statistically significant. When this study began, the author believed that mathematics instructors and computer science instructors would be lecture focused in their beliefs (possibly extremely so) and that biology and physics instructors would be student focused (possibly extremely so). Neither of these anticipated results occurred--there was no significant relationship found between the science taught and the teaching beliefs of an individual instructor. This is a fortunate finding, for it means that any method developed to address the teaching beliefs of an individual instructor might be able to be applied across scientific disciplines and to the community college science faculty as a whole.

The science taught by an instructor and BARSTL component scores were also analyzed using a one-way multivariate analysis of variance to see if there was a significant relationship between them. No significant relationship was found among any of the BARSTL component scores and the science taught by an instructor using statistical analysis. This again was somewhat surprising, for one might expect a mathematician or computer scientist (who do not generally apply the scientific method to their work) to have a different view of the scientific method (BARSTL component four) than a biologist or chemist (who actually use the scientific method in research). This was not found to be the case. Note that there was very little variation overall in any instructor's view of the scientific method--modern education has seen to it that all of the instructors have essentially a balanced view of the role of the scientific method in the classroom, regardless of whether or not they actively use it.

Research Question Seven

Research question seven asked: Is there a significant relationship between teaching philosophy (BARSTL score) and the state in which an instructor teaches? Is there a significant difference between BARSTL components and the state in which an instructor teaches?

The overall BARSTL score of instructors and the state in which the instructors teach were analyzed using a one-way univariate analysis of variance to see if there was a significant relationship between them. No significant relationship was found between overall BARSTL score and the state in which an instructor teaches. Though no statistically significant differences were found, instructors from Louisiana were the most student centered, with instructors from Alabama the most balanced in their teaching views. It would have been surprising for teaching beliefs to vary by state, but this was a factor worth investigating. If there had been a significant difference, differences in the administration and curricula of schools by state could have been examined to discover the reasons for the differences. As it is, however, there is no reason to do so. In addition, the lack of a significant difference between the teaching beliefs of community college science instructors across the different southern states means that the state in which an instructor teaches does not need to be taken into account when developing a uniform approach towards addressing teaching beliefs. Along with the results to research question six, this serves to simplify any future plans to address changing or adapting teaching beliefs of community college science instructors.

The state in which community college science instructors teach and the BARSTL component scores of these instructors were analyzed using a one-way multivariate analysis of variance to see if there was a significant relationship between them. No significant relationship was found. As in question six, the absence of evidence of a relationship here helps to support the idea that a single approach toward changing or adapting the teaching beliefs of community college science instructors may be viable across all of the southern states. If even a single component of the BARSTL had been influenced by the state in which an instructor taught, this relationship would have needed to be explored further using statistical methods.

Research Question Eight

Research question eight asked: Is there a significant relationship between teaching philosophy (BARSTL score) and birth order of the instructor? Is there a significant difference between BARSTL components and birth order of the instructor?

Overall BARSTL score and the birth order of community college science instructors were analyzed using a one-way univariate analysis of variance to see if there was a significant relationship between them. No significant relationship was found. Youngest children and oldest children were found to be the most student centered, while only children and middle children were found to have more balanced teaching beliefs, though these differences were not statistically significant. Unlike the other characteristics investigated here, birth order is an innate social aspect of a person which is essentially unchangeable. (Age naturally progresses, while the other criteria are clearly fungible). The author initially believed that these factors would not have a significant impact on the overall BARSTL score, but this question was asked to examine whether that assumption was valid. If birth order had been found to have a significant impact, that would have implied that many other background social criteria (such as race, gender, ethnicity, etc.)

of community college science instructors might also be worthy of investigation to see if they have an impact on teaching beliefs as well.

Birth order and BARSTL component scores of community college science instructors were also analyzed using a one-way multivariate analysis of variance to see if there was a significant relationship between them. As in research questions six and seven, this again supports the idea that a single approach toward changing or adapting the teaching beliefs of community college science instructors may be viable no matter the birth order of the instructors.

Research Question Nine

Research question nine asked: What do community college science instructors believe is the driving force behind making their discipline change? Is it driven by discoveries within the discipline? Is it driven by outside forces, such as politics?

This question was analyzed using both qualitative and quantitative methods--investigating both the belief of community college science instructors about what propels their discipline forward as well as the relationship of this belief to the BARSTL score of those instructors. Coding determined that there were three common answers to this question from community college science instructors: their discipline is primarily driven by politics and political forces, their discipline is primarily driven by technology, and their discipline is primarily driven by discoveries and change from within. By far the most popular answer, with almost double the other responses, was that politics propels the science disciplines forward. Many instructors were worried that politics and political interests influenced both science and science education quite heavily. They believed that the combination of regulations and research money served to direct the progression of their disciplines. Uniformly, the instructors who believed that politics and political forces were driving their discipline were quite upset at that fact and clearly did not like what they viewed as "outside forces" in their field.

The other two common answers, that technology or discoveries from within were the driving force behind change in the sciences, were much less popular. Instructors who focused on the role of technology mainly focused on the changes in the classroom caused by the introduction of many new types of technology. Most of these instructors were quite positive about technology as a force for change and used technology to allow them to conduct experiments and examples that previously would not have been possible (using computer simulations of plate tectonics, for example). A few instructors were upset at the role of calculators in reducing basic student skills, especially skills in arithmetic. Finally, some instructors took the traditional view that a science grows and advances by discovery and the scientific method, and that even today this is the primary way in which science grows as a discipline.

The relationship between the most common answers to this question and overall BARSTL score was investigated using a one-way univariate analysis of variance. No significant relationship was found between these responses and overall BARSTL score. Instructors who believed that politics was the driving force in their discipline were slightly more student focused than those who believed technology or discoveries propelled their discipline forward, but this difference was not significant.

This question, along with research question ten, eleven, and twelve, were investigated to see what shapes the belief structure of community college science instructors, and if this belief structure is open to change. This line of investigation was critical in understanding how to best approach changing the belief structure of community college science instructors. This particular question was asked to see what they believed was currently shaping their discipline, and if that was a viable way to use to change their belief structure moving forward. The responses show that the majority of community college science instructors currently believe that political influence is the primary factor in propelling their discipline forward. More so, they are quite wary of having political rules and regulations impact their role in the classroom. This means that any future program designed to alter the belief structure of community college science instructors needs to feel separate from the political and administrative structure of their schools.

Based on the results of this question and research question twelve (discussed below), teachers will most likely react quite negatively to what they see as another political intrusion in their classroom. Mandates or regulations imposed on them will almost certainly not have the desired result in changing their belief structure, and will only reinforce this current negative view of the political system. Instead, the results to this question imply that community college instructors might respond more positively to a voluntary program with limited incentives--in other words, positive rather than negative reinforcement.

Research Question Ten

Research question ten asked: Do community college instructors change their approach in the classroom after they begin teaching?

This question was analyzed using quantitative and qualitative methods--examining whether community college science instructors believe they have changed their approach since they started teaching and if this belief has a significant relationship to the overall BARSTL score. Virtually all of the community college science instructors participating (94%) believe that they have changed their teaching approach since they began their career. Most of these instructors stated that they changed in response to learning new techniques or teaching practices. The rest changed in response to the introduction of new technologies which made their previous teaching approach obsolete. The small minority of instructors who had not changed were either new instructors who had not yet had a chance to change, or older instructors who believed they were already teaching using the best approach possible. Overall, clearly the responding instructors are ready and willing to change what they believe a proper teaching approach is, given the right circumstances.

The relationship between these responses and overall BARSTL score was analyzed using a one-way univariate analysis of variance. No significant relationship was found. The few instructors who had not changed their teaching approach were much more teacher-centered in their approach than the other instructors, but this difference was not significant.

The response to this question was quite exciting. The typical community college science instructor believes that they have changed their approach in the classroom since they started teaching, and this change is in response to learning new methods or techniques they wanted to apply in the classroom. The key is that these instructors acknowledge that they have changed their teaching approach. This would not have happened had these instructors not believed that the new teaching approach was better suited for their classroom.

Whether or not they actually changed is not as significant for our purposes as the fact that they believe that they have changed. This gives researchers a method in which to try to change teaching beliefs. The response to this question shows that exposure to new techniques that may be better suited for a teacher's classroom has the potential to cause an instructor to attempt to change their teaching style. This change almost certainly happens because the instructor *believes* the new teaching approach is better suited for their classroom. Contrast this to the earlier examples seen in Yerrick and colleagues' research, where teachers were unable to change their teaching approach because their belief systems remained the same (Yerrick et al., 1997). In other words, a change in belief happens before a change in practice. Clearly, this idea may be useful in designing a method to change teaching beliefs of community college science instructors.

Research Question Eleven

Research question eleven asked: Do community college instructors believe their teaching style impacts how well their students learn in the classroom?

This question was also examined using qualitative and quantitative methods--to see if community college science instructors believe their individual approach in the classroom makes a difference in student performance. The vast majority of instructors surveyed believed that their approach in the classroom not only made an impact, it was the determinative factor in how well students performed in the classroom. A small minority of instructors instead believed that student performance was mainly dependent on innate ability and effort of the student, and that the instructor's approach made only a small difference in the outcome. Only two instructors believed that their approach made absolutely no difference in whether or not students performed well in the classroom.

Overall, teachers were quite confident that they were personally making a difference in the lives of their students and helping them to learn.

The relationship between the two groups of instructors who believed that their approach helped their students and overall BARSTL score was examined using a t-test. The t-test found no significant relationship, but only barely ($p=.054$). The difference between the two groups was comparatively large but not significant, with instructors who believe that their approach is the determinative factor in student success being much more student-focused than the group of instructors who believe that students have control over their own success in the classroom. This relationship is counterintuitive, and so it definitely warrants further investigation. It is possible that the instructors who believe that their approach makes a definitive difference believe in their ability to reach a student, and that is why they are more student-focused.

Overall, this question was asked to judge whether or not community college science instructors had faith in the approach they were currently using in the classroom. That is, do they believe in how they are currently teaching? A teacher with confidence in the method they are currently using would surely believe that they can impact every child in their classroom significantly, while a teacher with little confidence in their approach might believe that time with students is not necessary and does not make a difference. Also of note, this confidence arises out of a belief that what they are doing in the classroom is the correct approach. These instructors will naturally not want to change what they are doing in the classroom, because they believe that they are currently reaching students and changing them.

Any approach designed to alter teaching beliefs of these science instructors must take this innate confidence in their current approach into account. These science instructors may not be as successful in teaching their students as they think they are, and it may be possible to use cognitive dissonance to break this belief structure and reform it anew. For example, an instructor thinks they are approaching students in the best and most appropriate way. Now allow this instructor to observe another instructor using a different approach based on a different set of teaching beliefs who is able to get more out of their students. Clearly the method the first instructor thought was best is not the best.

The actual methods used are not important--what is important is that the belief structure behind the new method is a belief structure that is more in line with the current curriculum. If the old belief structure is broken, then the new structure that forms should be more in line with the new knowledge the instructor has. Then the science instructor will, under their own volition, work to create a new teaching style out of this belief system. Responses to research question eleven clearly show that community college science instructors are more than willing to change their teaching approach if they feel it is not effective. This "feeling" is belief in their current approach. So, then, it appears that a viable method of changing the teaching beliefs of an instructor is to demonstrate that the instructor's current belief structure is founded on faulty premises and misguided.

Research Question Twelve

Research question twelve asked: Do community college instructors believe that all of the instructors in a department should use a similar teaching style?

Qualitative methods were used to examine whether community college science instructors believe that all instructors in a department should use a similar teaching style.

Overwhelmingly (92%), community college science instructors believe that a department should not use a similar teaching style. Some instructors voiced concerns that forcing the entire department to use a same or similar teaching style would violate notions of academic freedom. Most instructors, though, were concerned that standardization of teaching styles would prevent them from adapting their lessons to their individual classes. They also worried that students would lose academic freedom and lose the ability to choose between different styles of instruction. The small number (4%) of instructors who believed that teaching styles should be standardized argued that it is difficult to improve a department where every instructor takes a different approach. A similar number of instructors argued that standardization was appropriate in some laboratory classes but not in lecture classes.

This poses a special problem for the area of best practices. One of the essential tools used to better teaching methods in all areas is the identification and replication of best practices--methods and techniques which work especially well (Nitecki, 2011). The response to this question indicates that seeking to have community college science instructors institute similar best practices may be problematic. However, the instructors may have a point.

A teaching approach may certainly be the best way for one instructor with a certain set of teaching beliefs to reach a student. However, if a teacher has a different set of beliefs, that approach may conflict with them. This conflict will result in an ineffectual application of the new teaching approach, regardless of the effort or energy put into it by the second instructor (Cross, 2009). For example, in a recent article Better (2013) describes an intensely exciting, student focused sociology classroom. She engages with students on a personal level. However, she notes that her approach is different from the ordinary instructor, saying that her class is not a "read the book take the test" type of class (Better, 2013). Though her approach works well for her, clearly not every instructor is suited to this approach. If another instructor believes that reading textbooks and gaining knowledge before discussion is important, they will be quite unhappy with Better's approach. This unhappiness will translate into an ineffectual application of Better's original approach, despite the best efforts of the instructor (Cross, 2009). Simply put, best practices for one instructor simply may not be best practices for other instructors in many or even most situations. At the very least, the teaching beliefs of both the instructor being observed as a model and the instructors who are targeted for change must be taken into account.

However, all is not lost. The key here is that changing teaching approach without changing teaching belief will be ultimately ineffectual (Sampson et al., 2013). The researchers' and administrators' role, then, is to find a way to harmonize teaching belief and teaching approach to find success in the classroom (Cross, 2009). From the answers to research questions ten and eleven, it can be seen that community college science instructors are naturally seeking ways to improve themselves, including changing their approach and beliefs if necessary. The role then of an administrator is to assist this natural process of change without causing resentment embodied in the answer to this question to come forth. This role of community college administrators will be discussed in more detail in the next section.

Implications for Policy and Practice

The primary implication of this study is that curricula which are extremely student centered or teacher centered should be avoided by community colleges. This study showed that community college science instructors are generally balanced between teacher focused and student focused in their teaching beliefs. No community college instructor examined had an extremely teacher centered viewpoint, and very few had an extremely student centered viewpoint. Balanced approaches which rely on both elements of a student centered view as well as a teacher centered view should be compatible with the vast majority of community college science instructors.

A balanced approach might take the form of a lecture whose scope and progress is modified based on student performance and feedback. This type of teaching would be grounded in the teacher centered view, but with lessons learned from student centered beliefs. Another balanced approach might use group and other team assignments to reinforce lessons initially taught in lecture.

This holds a special implication for online learning. Online learning has the potential to be either very student centered, with lessons individualized for each student--almost a personal relationship. It can be very teacher centered, with all of the learning coming from prerecorded lectures and impersonal generalized responses. The typical community college science instructor needs to avoid both of these extremes, because they go against the typical community college science instructor's belief in how a class should be taught. Instead, elements from both of these approaches should be incorporated into a balanced whole.

The second implication of this study is that age may be a determining factor in the teaching belief of a community college instructor, with younger teachers having a more student centered focus and older instructors having a more balanced view of the classroom. Immediately, this leads to the conclusion that younger teachers should be partnered with younger teachers, and older teachers with older teachers, when searching for ways to improve the performance of an individual instructor. If instructors have a similar approach to the curriculum, then it would be easier for partners to learn from one another. Conversely, if instructors have opposing approaches to the curriculum, it would be difficult or impossible for them to find teaching methods one instructor is using that the other would be able to use in the classroom.

The third primary implication of this study is that directing community college science instructors to change to have a similar teaching style throughout their department is a very unpopular notion with them. The vast majority of community college science instructors actively opposed the idea. Part of this opposition clearly comes from the notion that most community college science instructors surveyed believed that they are currently making a positive difference in the classroom. Clearly they would not want to put their students at risk. Another part of this opposition comes from what community college science instructors viewed as the undue influence of politics in the classroom. Any standardization push may be viewed as part of the reach of politics and may be reacted to quite negatively.

However, the surveyed community college science instructors were willing to change their teaching approach if they thought it was necessary. The majority surveyed had in fact changed their approach since they started teaching. The key idea for administrators to keep in mind is that the community college science instructors need to believe that the need for change comes from within. If instructors see a need for change, they will try to change. If they do not see a need for change, they will fight it.

This presents a special challenge for administrators. Community college administrators need to find a way for their instructors to improve while not engendering hostility in the faculty. It is possible that a solution to this is having a curriculum which contains elements of both teacher and student focus--where teachers can pick and choose elements and approaches based on the topic covered.

The Everyday Mathematics elementary mathematics curriculum can be seen to work in this fashion. The curriculum itself is composed of many different types of games and other activities, all of which work to reinforce concepts taught in a more general setting. The ratio of activities to direct instruction is at the discretion of the instructor. Every classroom implementing Everyday Mathematics will have similar elements, but each classroom will be tailored to the beliefs of the individual instructor and the needs of the students (CEMSE, 2011).

Ultimately, if community college science instructors are constantly changing their approach, it would seem wise for administrators to give them the tools and information necessary to change their approach to what the instructors themselves believe to be optimal. A college level approach similar to Everyday Mathematics would allow a single curriculum to be compatible with multiple different types of teaching beliefs. It also gives community college science instructors the ability to effectively change when the desire manifests itself from within.

Limitations

The limitations of this study are noted to aid future research. First, this study is limited by its sample. This study exclusively examined community college science instructors. Instructors at a four year institution or in a K-12 environment may have quite a different view on teaching beliefs. Also, this study is limited to community college science instructors from the southeastern United States. Every eligible instructor in Alabama, Louisiana, Mississippi, and Tennessee was invited to participate in this study, and a full 10% did attempt to participate in this study. However, instructors from other parts of the country may have very different belief systems. In addition, though non-academic faculty were invited to participate in the study, not a single non-academic community college science instructor did so. Their participation may have changed the outcome of the study, perhaps significantly.

A second limitation of this study is that the group sizes used for analysis were uneven. A much larger sample that could have been randomly selected from would have helped here, but unfortunately community college science instructors are not great in number. Every community college science instructor in four states amounted to only around 1200 individuals.

A final limitation of this study is social desirability bias, where the respondents answer questions in such a way as to make themselves look like better instructors. Responses to the short answer questions appear to be frank and honest, especially the comments on politics and standardization of teaching approaches, but one must always be careful that respondents actually believe what they write. Inclusion of short answer questions helps to alleviate natural concerns that one researching in this area may have about this sort of bias, but one can never be completely confident in the responses given.

Recommendations for Future Research

Using quantitative analysis in this area is comparatively new, so there are many possible areas of future study. One area which is quite important is continuing to measure the teaching beliefs of instructors. Extension of this study using a larger, nationwide sample of community college science instructors would allow the ideas and conclusions explored in this study to be substantiated and explored much more fully. Alternatively, the population itself could be changed--four year college science instructors as well as K-12 science instructors are both interesting and distinctly different populations worthy of study. Researching all of these populations in turn would allow a researcher to get a national picture of teaching beliefs and how they vary among populations, which would be useful for further research.

An additional area of research which is recommended is a longitudinal study where the teaching philosophies of a small group of teachers are studied throughout the first five or ten years of their career. This would allow researchers to begin to answer the question of whether teaching philosophy changes with age or if teaching philosophy varies generationally--i.e., by age group. If the teaching philosophy remains static in this group, this would point towards a more rigid, unchanging teaching philosophy where teachers improve by developing more and better teaching methods. If the teaching philosophy changes over time, especially if it becomes more balanced, that would support the notion that community college science instructors have an ever evolving teaching philosophy which changes according to what they see in the classroom.

A third area of research which is recommended is the quantitative analysis of teaching methods and entire curricula to measure how teacher centered or student centered they are. Analysis of this type would allow community colleges to better match curricula with instructors. In addition, an analysis of this type would open the door to many different types of quantitative analysis of the relationship between instructor and curriculum. The most important item to be researched here is a quantitative analysis of the gain or loss in student performance achieved by an instructor using an approach which harmonizes or does not harmonize with the instructor's teaching beliefs. Are student gains from a student centered teacher using a student centered curriculum equal to student gains from an instructor centered teacher using an instructor centered curriculum? What about the reverse? Are some curricula so effective that the teacher's teaching beliefs should not be taken into account? What other factors could be used to rate curricula so that a comparison is equal? This is a completely different area of study which seems wide open at the moment.

If the relationship between teaching belief and the approach taken by curricula are found to have a significant effect on student performance, then teaching beliefs themselves should be consistently measured when testing new curricula. This would allow curriculum designers to know who is best suited for their curriculum, and serve as a guide for administrators when adopting new curricula.

Note also that examining an instructor in the classroom would allow analysis of student perception of their instructor’s teaching beliefs. A comparison might be made between how students perceive an instructor's teaching beliefs and how the instructor perceives their own teaching beliefs. Students actually experience the teaching of an instructor, and they clearly know whether they are welcome to speak in a classroom or not. They also would have personal, in depth knowledge of how the instructor works with and instructs students. This knowledge could be compared with results from the BARSTL, or a modified BARSTL such as was used in this study. A comparison between the two might help to further clarify how an instructor views their own teaching beliefs and could help further define teaching beliefs as a whole.

Finally, the next goal for this researcher will be to undertake a design of the college mathematics curriculum for remedial mathematics and college algebra based on the initial principles given in the implications for policy and practice of this chapter. This curriculum will attempt to have options at every step for instructors with different teaching beliefs while still meeting the standard goals and objectives of a basic mathematics course. The goal here would be a unified curriculum that is most compatible with instructors who have a balanced teaching approach between student and teacher centered points of view. The tools within the curriculum would also allow a teacher centered or student centered instructor to build an effective class which teaches the same material in a way most suited to that particular instructor. Such a curriculum should be compatible with most instructors--ideally harmonizing with most of them and bringing all of the benefits that such harmonization would normally provide, as outlined in Chapter II, principally the ability to deal with unusual situations and be a more adaptable and effective instructor. If the research described in the previous paragraphs finds a significant relationship between harmonization of teaching beliefs with teaching approach and student performance in the classroom, a curriculum of this type would also be perfectly suited to optimize this relationship in every classroom, without the need of adopting a different curriculum or approach for each instructor.

APPENDIX A

THE BARSTL QUESTIONAIRE

How People Learn About Science

The statements below describe different viewpoints concerning the ways students learn about science. For the purpose of this questionnaire, "science" means any STEM field: including any of the sciences, technology, engineering, or mathematics. Based on your beliefs about how people learn, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree
NR: No Response/I do not wish to respond

1. Students develop many ideas about how the world works before they ever study about science in school.

SD D A SA NR

2. Students learn in a disorderly fashion; they create their own knowledge by modifying their existing ideas in an effort to make sense of new and past experiences.

SD D A SA NR

3. People are either talented at science or they are not, therefore student achievement in science is a reflection of their natural abilities.

SD D A SA NR

4. Students are more likely to understand a scientific concept if the teacher explains the concept in a way that is clear and easy to understand.

SD D A SA NR

5. Frequently, students have difficulty learning scientific concepts in school because their ideas about how the world works are often resistant to change.

SD D A SA NR

6. Learning science is an orderly process; students learn by gradually accumulating more information about a topic over time.

SD D A SA NR

7. Students know very little about science before they learn it in school.

SD D A SA NR

8. Students learn the most when they are able to test, discuss, and debate many possible answers.

SD D A SA NR

Lesson Design and Implementation

The statements below describe different ways science lessons can be designed and taught in school. Again, "science" means any STEM field or related fields. Based on your opinion of how science should be taught, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

9. During a lesson, students should explore and conduct their own experiments with hands-on materials before the teacher discusses any scientific concepts with them.

SD D A SA NR

10. During a lesson, teachers should spend more time asking questions that trigger divergent ways of thinking than they do explaining the concept to students.

SD D A SA NR

11. Whenever students conduct an experiment during a science lesson, the teacher should give step-by-step instructions for the students to follow in order to prevent confusion and to make sure students get the correct results.

SD D A SA NR

12. Experiments should be included in lessons as a way to reinforce the scientific concepts students have already learned in class.

SD D A SA NR

13. Lessons should be designed in a way that allows students to learn new concepts through inquiry instead of through a lecture, a reading, or a demonstration.

SD D A SA NR

14. During a lesson, students need to be given opportunities to test, debate, and challenge ideas with their peers.

SD D A SA NR

15. During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.

SD D A SA NR

16. Assessments in science classes should only be given after instruction is completed; that way, the teacher can determine if the students have learned the material covered in class.

SD D A SA NR

Characteristics of Teachers and the Learning Environment

The statements below describe different characteristics of teachers and classroom learning environments. Based on your opinion of what a good science teacher is like and what a classroom should be like, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

17. Students should do most of the talking in science classrooms.
SD D A SA NR
18. Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.
SD D A SA NR
19. In science classrooms, students should be encouraged to challenge ideas while maintaining a climate of respect for what others have to say.
SD D A SA NR
20. Teachers should allow students to help determine the direction and the focus of a lesson.
SD D A SA NR
21. Students should be willing to accept the scientific ideas and theories presented to them during science class without question.
SD D A SA NR
22. An excellent science teacher is someone who is really good at explaining complicated concepts clearly and simply so that everyone understands.
SD D A SA NR
23. The teacher should motivate students to finish their work as quickly as possible.
SD D A SA NR
24. Science teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.
SD D A SA NR

The Nature of the Science Curriculum

The following statements describe different things that students can learn about in science while in school. Again, "science" means any STEM field or related fields. Based on your opinion of what students should learn about during their science classes, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

25. A good science curriculum should focus on only a few scientific concepts a year, but in great detail.
SD D A SA NR

26. The science curriculum should focus on the basic facts and skills of science that students will need to know later.

SD D A SA NR

27. Students should know that scientific knowledge is discovered using scientific methods.

SD D A SA NR

28. The science curriculum should encourage students to learn and value alternative modes of investigation or problem solving.

SD D A SA NR

29. In order to prepare students for future classes or a career in science, the science curriculum should cover as many different topics as possible over the course of a semester.

SD D A SA NR

30. The science curriculum should help students develop the reasoning skills and habits of mind necessary to do science.

SD D A SA NR

31. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with “define the problem” and ends with “reporting the results.”

SD D A SA NR

32. A good science curriculum should focus on the history and nature of science and how science affects people and societies.

SD D A SA NR

Free Response Essay Questions

Please respond to the given questions. There is no "right" answer--respond based on your own personal thoughts and feelings. Please write as much or as little as you feel is necessary to answer the question.

33. What do you believe is the principal driving force behind making your discipline change? Is it driven by discoveries within your discipline, such as new theories or techniques? Is it driven by discoveries outside of your discipline, such as new technologies? Is it driven by external factors, such as politics?

34. Have you changed your approach in the classroom since you started teaching? Why?

35. Do you feel like your teaching style impacts how well your students learn in the classroom? How much of an impact do you think it has?

36. Do you feel that all of the instructors in a department should use a similar teaching style? Why or why not?

Demographics

37. On average, how many hours do you teach each week?

1-3 4-9 10-15 16+ NR

38. How many years of teaching experience in the sciences do you have?

0-2 3-5 6-10 11-15 16+ NR

39. How old are you?

21-35 36-49 50-64 65+ NR

40. What science do you primarily teach as an instructor?

Applied Sciences (Including career training and certificate courses)
Biology/Biological Sciences
Chemistry
Computer Science
Mathematics/statistics
Physics/Physical Science
Other __________

41. In what state do you teach?_________________________

42. Do you have any siblings? Were you born before or after them?

Only Child Youngest Child Middle Child Oldest Child NR

APPENDIX B

CONSENT FORM

The purpose of this research project is to investigate teaching beliefs of community college science instructors. This is a research project being conducted by Michael Howard at The University of Southern Mississippi. You are invited to participate in this research project because you are a community college science instructor. Here, science includes any STEM or related field, including but not limited to mathematics, physics, chemistry, biology, and applied sciences, including Career-Technical instructors who teach primarily science-based courses of study.

Your participation in this research study is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw at any time. If you decide not to participate in this study or if you withdraw from participating at any time, you will not be penalized.

The procedure involves filling an online survey that will take approximately 20 minutes. Your responses will be confidential and we do not collect identifying information such as your name, email address or IP address. The survey questions will be about your personal teaching beliefs--how you think a classroom is best run, how you think students best learn, etc.

We will do our best to keep your information confidential. All data is stored in a password protected electronic format. To help protect your confidentiality, the surveys will not contain information that will personally identify you. The results of this study will be used for scholarly purposes only and may be shared with representatives of The University of Southern Mississippi. At the conclusion of the study, all physical copies of the data will be destroyed, and digital copies will be permanently wiped.

If you have any questions about the research study, please contact Michael Howard at 205-383-6070. This project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research subject should be directed to the chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-6820

ELECTRONIC CONSENT: Please select your choice below.
Clicking on the "agree" button below indicates that:

- you have ready the above information
- you voluntarily agree to participate
- you are at least 18 years of age

If you do not wish to participate in the research study, please decline participation by clicking on the "disagree" button.

__ agree
__ disagree

APPENDIX C

RECRUITMENT DOCUMENT

Hello fellow community college instructor,

I am requesting your help in the completion of my dissertation project. I am trying to understand the emotions and beliefs that instructors have about STEM (science, technology, engineering, and mathematics) fields and STEM related topics in the classroom. Since I am examining feelings and emotions, there are no correct answers to these questions and no value judgements will be correlated with your response. In addition, your responses are completely anonymous to everyone, including me. I only ask that you give me your true feelings and emotions on the topic.

I know that you are quite busy, but the survey should only take around 10-20 minutes to complete. I really appreciate your help!

Follow this link to the Survey:
${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}

I invite you to look for my dissertation at The University of Southern Mississippi library website next year to read the results of the study.

Thank you again and have a wonderful day!

Michael Howard
Mathematics Instructor
Copiah-Lincoln Community College

NOTE: This project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research subject should be directed to the chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS
39406-0001, (601) 266-6820

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

APPENDIX D

INSTITUTIONAL REVIEW BOARD APPLICATION

ORI | Office of Research Integrity

INSTITUTIONAL REVIEW BOARD

HUMAN SUBJECTS RESEARCH APPLICATION FORM

HUMAN RESEARCH APPLICATION PROCEDURES

Use this form to apply for IRB review. IRB approval is required before human subjects research can begin.

- Before completing this form, review the information included on the sample consent forms and FAQ section of the IRB website: http://www.usm.edu/research/institutional-review-board.
- Department chairs and, if applicable, research advisors must review the completed form and provide authorization where indicated.
- Department chairs must submit completed versions of this form with all necessary authorizations to irb@usm.edu using their Southern Miss email address.

Last Edited January 22nd, 2013

SECTION 1: INVESTIGATOR INFORMATION

Project Title: A STUDY OF THE TEACHING BELIEFS OF THE MODERN POST SECONDARY SCIENCE INSTRUCTOR AND IMPLICATIONS THEY MAY HOLD FOR THE FUTURE OF SCIENCE EDUCATION

Principal Investigator:Michael Howard		Phone:205-383-6070	USM Email: michael.howard@eagles.usm.edu
Campus ID:w301430	College: CoST	Department:CSME	Department Phone:601-266-4739

Research Purpose (check one):	**Student Research Advisor (if applicable)**	**Funding Agency/Sponsor (if applicable)**
☐Undergraduate project ☒Graduate project ☐Faculty or staff research	Name: Dr. Sherry Herron	Organization: N/A
	Phone: 601-266-4739	
	USM Email: sherry.herron@usm.edu	Grant #:

List USM affiliated investigators; completion of CITI Common and Human Subject Research Courses is required.	**Name**	**Faculty or Staff**	**Graduate Student**	**Under-graduate**	**Project Role**
	Michael Howard	☐	☒	☐	PI
		☐	☐	☐	
		☐	☐	☐	
		☐	☐	☐	

If other individuals will be involved in data collection, describe their role and their training.

N/A

List all Non-USM affiliated investigators.	**Name**	**University or Institution**	**Project Role**
	N/A		

Describe your expertise and qualifications related to this research:

I am a doctoral student in Science and Mathematics Education. I have also been a community college science instructor for two years. I have had training through my coursework which has prepared me for this research. I currently teach statistics and I have assisted others in performing the analysis which I will do in this project.

SECTION 2: RESEARCH PROCEDURES

Briefly describe the project and its goal(s) in two to three paragraphs.

The goal of this project is to examine teaching beliefs of community college science instructors. Teaching beliefs can be thought of as the thoughts and preconceptions that a teacher brings to the classroom. Prior research shows teaching beliefs impact a teacher's performance in the classroom--if a teacher does not believe the type of curriculum they are implementing will be successful in helping students, then it tends not to be successful, regardless of other factors. The topics that will be explored in this study include: how people learn about science lesson design and implementation, characteristics of teachers and the learning environment , and the nature of the science curriculum. This research will examine the relationship between these topics and how long a teacher has been in the classroom, what subject the teacher teaches, and other demographic components, to help community colleges better understand their faculty.

Are any of the subjects under 18 years of age?

☐Yes ☒No

Note: Parental consent is required for participants under the age of 18.

Describe subject population, number of subjects to be included, and criteria for selection.

Emails will be sent to community college science instructors asking them to participate in the study. These emails will include a link to the online survey that is attached to this application. Email addresses will be taken from publicly available lists of teachers' email addresses. All subjects will be active community college science instructors. Teachers in multiple southern states will be given an opportunity to complete the survey, though due to personal contacts it is expected that most of the responses will come from Mississippi and Alabama.

Teachers will complete the survey on their own time, and should not require the collaboration of the school or school system. 40 completed questionnaires are needed for the statistical analysis in this work, though more responses are expected.

How will participants be recruited?

☐Class announcement ☐Oral Announcement ☒E-mail announcement
☐Posted campus advertisement ☐Television, Radio or Newspaper ad ☐Advertising Agency
☐Other (explain):

For adult subjects, how will you verify that individuals are over 18?

☒Survey or interview
☐No adults will be participating in this research
☐Other (explain):

Indicate consent procedures (check all that apply):

☐Oral presentation
☐Information letter
☒Short Consent Form
☐Long Consent Form
☐Assent form (children or subjects with disabilities)
☐Request for waiver of consent
☐Not applicable

Detail procedures for obtaining participants' consent or justify request for waiver.

A short form is appropriate here because this study is not longitudinal in nature and does not pose any significant risk to participants. The consent form will be provided digitally to respondents, and must be digitally signed by participants before they will be allowed to take the questionnaire [consent form is attached]. The provided short form clearly states what will be required from participants and meets the requirements set out for informed consent.

How many interactions will be required with each subject?	Maximum length of each interaction:	Where will interactions take place? (check all that apply):
☒1 ☐2 - 3 ☐4 – 9 ☐10 or more	☐Less than 10 minutes ☒Less than an hour ☐Less than three hours ☐Three hours or more. ☐No direct interaction with subjects	☐On campus ☐Off campus ☒Online

Indicate means of data collection (check all that apply).	Do any of the following apply to your study?
☐Personal Interview ☒Questionnaire or survey ☐Audio or video recording ☐Behavioral Observation ☐Focus Group Inquiry ☐Other (explain below):	Use of human biological samples ☐Yes ☒No Use of physical exercise ☐Yes ☒No Medical examinations or procedures ☐Yes ☒No Use of drugs or biological products ☐Yes ☒No

Give a step by step explanation of human subjects data collection procedures.

Emails will be sent to community college science instructors asking them to participate in the study. These emails will include a link to the online survey that is attached to this application. Email addresses will be taken from publicly available lists of teachers' email addresses. All subjects will be active community college science instructors, and so none should be under the age of 18. Teachers in multiple southern states will be given an opportunity to complete the survey, though due to personal contacts it is expected that most of the responses will come from Mississippi and Alabama. For demographic purposes, teachers will be asked to give the state in which they live, but no other identifying information will be collected.

Teachers will complete the survey on their own time, and should not require the collaboration of the school or school system. 40 completed questionnaires are needed for the statistical analysis in this work, though more responses are expected.

Respondents will complete a number of multiple choice and short answer questions. This will be completed using the website Qualtrics.com and respondents will be anonymous. All respondents will complete the same instrument, which is estimated to take 20 minutes to finish.

Does your research involve only the collection of anonymous data? ☒Yes ☐No	**Note: 'Anonymous' means that investigators cannot associate the data with individual subjects and vice versa. Electronic surveys must be conducted via websites that do not link responses to e-mail addresses or other identifiers. Personal interviews are not anonymous.**
Does your research involve sensitive information? ☐Yes ☒No	**Note: Sensitive information may include (but is not limited to) information about sexual activity, drug usage, criminal behavior, financial or medical data, and religious views.**
Does your research involve hidden video or audio recordings or deception? ☐Yes ☒No	**Note: Deception includes any information or procedure that misleads a subject intentionally.**

SECTION 3: RISKS AND BENEFITS

Indicate all potentially vulnerable subjects involved in the study.	Detail the methods that will be employed to protect vulnerable subjects.
☐Children ☐Mentally ill patients ☐Nursing home patients ☐Pregnant females ☐Prisoners ☐HIV positive individuals ☐Other ☒Not applicable	N/A

If your research involves prisoners, explain how it is directly relevant to prisoners or the prison system (check all that apply): ☐the causes and/or effects of incarceration ☐the process of incarceration ☐prisons as institutional structures ☐the conditions of prisons or prisoners ☐procedures for improving the wellbeing of prisoners ☐other (explain):	**Note: All research involving prisoners requires compliance with federal regulations pertaining to biomedical and behavioral research involving prisoners as listed in FR 53655 Subpart C. Research must be directly relevant to prisons or prisoners (e.g. the effects of incarceration, criminal behavior, prison infrastructures, etc.). Completion of the CITI Research with Prisoners Module is also required.**
How will you maintain confidentiality? ☒Anonymous data ☒Electronic data will be password protected ☐Physical data will be locked in a file drawer ☐Public/non-confidential data ☐Other (explain):	Describe final disposition of data. After completing the study, all data associated with the survey will be permanently deleted from Qualtrics. Any digital media that may contain confidential data will also be permanently erased.
Risks, inconveniences, or discomforts subjects are likely to experience (check all that apply): ☐Physical ☐Legal ☐Psychological ☐Social ☐Financial ☐Other ☐Occupational ☒None	Detail potential risks, inconveniences and discomforts subjects are likely to experience, if any. N/A
Describe the methods that will be employed to mitigate any potential risks, inconveniences or discomforts. N/A	
Describe any potential benefits subjects may gain as a result of participation. Ultimately, the benefits of this study will accrue to the community college system as a whole, rather than the individual participants. The results of this study will allow institutions to identify aspects of an instructor's teaching beliefs which are not in alignment with current curricula and work to change these beliefs.	
List all incentives subjects will receive for their participation. None	**Note: If class credit will be given for participation, describe what other options exist for nonparticipants to receive the same credit.**
If individuals are unwilling or unable to complete their participation, how will their incentives be distributed? ☐They will still receive all incentives. ☐They will be informed that they will receive no incentives. ☐They will receive partial incentives (explain):	
SECTION 4: CHECKLIST AND AUTHORIZATION	
The following documents must be attached to this form: ☒CITI Common Course Certificate ☒CITI IRB Course Certificate ☒Research proposal approval from dissertation or thesis committee (if applicable) ☒Study recruitment documents (if applicable) ☒Survey questions (if applicable) ☐Permission letter from external organization participating in the project (if applicable) on official letterhead ☐Assent form for minors (if applicable) ☒Consent forms (long or short if applicable) and any related documents (such as an oral script or information letter) ☐Letter to parents (if applicable) **Instructions for Attaching Documents:**	

1) Place the cursor where you want the attachment to appear.
2) Select the "Insert" tab at the top of MS Word.
3) Select "Object," located on the far right of the tool bar (PC) or the bottom of the list (MAC)
4) Select the "Create from File" tab and check the box that states "Display as Icon."
5) Browse to the location of your document, and double click on it.
6) Repeat these steps for each document to be attached.

Note for Mac Users: Word for MAC is unable to attach .pdf files, so you will have to first save the Citi certificates or any other .pdf files you intend to attach as a .doc or .rtf file before attaching them. There are several ways to accomplish this. You may use Adobe to open the file and then select "File" and "Save as" and change the file type to an .rtf or .doc format. Alternatively, you may also download or create your own .pdf to .doc application.

Attach all relevant documents in this section:

CITI core certificate.xps

CITI IRB Certificate.xps

Instrument.xps

Consent Form.xps

Research Proposal Approval.xps

Recruitment Document.xps

Instructions for Authorization:

1) Type your name and date in the appropriate box.
2) Graduate students should email the form to their advisors, who should add their name and then send it to department chairs for review. Department chairs should add their name and send the finalized form with all required authorizations to irb@usm.edu.

By typing my name below, I acknowledge that I have read, understood, and approve of the information contained herein.

Michael Howard		**Sherry Herron**
Primary Investigator	**Student Advisor (if applicable)**	**Department Chair**
3/6/2014		**3/6/2014**
Date	**Date**	**Date**

APPENDIX E

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional-review-board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **14040403**
PROJECT TITLE: **A Study of the Teaching Beliefs of the Modern Post Secondary Science Instructor and Implications they May Hold for the Future of Science Education**
PROJECT TYPE: **New Project**
RESEARCHER(S): **Michael Howard**
COLLEGE/DIVISION: **College of Science and Technology**
DEPARTMENT: **Center for Science and Math Education**
FUNDING AGENCY/SPONSOR: **N/A**
IRB COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **04/16/2014 to 04/15/2015**

Lawrence A. Hosman, Ph.D.
Institutional Review Board

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