EFFECT OF THE SCIENCE TEACHING ADVANCEMENT THROUGH MODELING PHYSICAL SCIENCE PROFESSIONAL DEVELOPMENT WORKSHOP ON TEACHERS’ ATTITUDES, BELIEFS AND CONTENT KNOWLEDGE AND STUDENTS’ CONTENT KNOWLEDGE

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A Thesis

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The Science Teaching Advancement through Modeling Physical Science (STAMPS) professional development workshop was evaluated for effectiveness in improving teachers’ and students’ content knowledge. Previous research has shown modeling to be an effective method of instruction for improving student and teacher content knowledge, evidenced by assessment scores. Data includes teacher scores on the Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992) and the Chemistry Concept Inventory (CCI; Jenkins, Birk, Bauer, Krause, & Pavelich, 2004), as well as student scores on a physics and chemistry assessment. Quantitative data is supported by teacher responses to a post workshop survey and classroom observations. Evaluation of the data shows that the STAMPS professional development workshop was successful in improving both student and teacher content knowledge. Conclusions and suggestions for future study are also included.
For my parents – Jeff and Irene
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I would like to acknowledge my advisor, Tracy Huziak-Clark for her support throughout this research, and to my other committee members for their support and insight.

I would like to acknowledge my parents – Jeff and Irene, for all they have done for me and for instilling so great a passion for science in me. Without them, I would have never come this far.

I also cannot forget all the wonderful science teachers I have had over the years who have helped me to grow into the educator I am today.

Lastly, to all my friends and family for the support and encouragement they have provided each and every day.
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CHAPTER ONE: INTRODUCTION

American students continue to fall behind in math and science in comparison to their counterparts in most industrialized nations. According to the Trends in International Math and Science Study (TIMSS), in 2011, United States fourth graders were outperformed in science by fourth grade students from 6 of the 57 participating countries, while for three countries there was no measurable difference. Even more alarming, United States eighth grade students were outperformed by 12 of the 56 participating countries, while 10 countries had no measurable difference (TIMSS, 2011). Furthermore, in 1996, the National Research Council published National Science Education Standards which “describe essential science content students need to know and the value of cooperation and collaboration in science” (Munck, 2007, p. 13). Such studies and statistics represent the growing need for updated pedagogy and best practices in science education. One way the United States has addressed such statistics is through professional development and inquiry based pedagogy, i.e., experimenting, collecting and interpreting data, and discussing outcomes (Munck, 2007). The Next Generation Science Standards (NGSS) describe a framework in which “Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge” (NRC, 2012, p. 27). One dimension of these new standards focuses on scientific and engineering practices, as development of students’ ability to participate in science inquiry has been a focus of the development of the standards (NRC, 2012).

Context of the Study

The Science Teaching Advancement through Modeling Physical Science (STAMPS) professional development workshop, offered through Bowling Green State University and funded by the Ohio Board of Regents’ Improving Teacher Quality program, seeks to work with
high school physical science teachers to improve instruction through pedagogy and content knowledge. The STAMPS program has been implemented and evaluated for three years, with the focus of this research being the third year of the program, STAMPS III. STAMPS III was funded in January 2013 and implemented from July 2013 through June 2014. The four key goals STAMPS sought to achieve are as follows:

1. Improve student learning in physical science
2. Improve teachers’ physical science knowledge
3. Improve teachers’ beliefs and behaviors regarding science teaching
4. Support teachers’ use of the modeling framework to teach physical science.

Throughout this professional development, the project sought to achieve these goals through teachers’ participation in the workshop by providing the skills and tools necessary to improve pedagogy and content knowledge. STAMPS III was led by co-investigators, one an education expert to aid in the development of the workshop to improve pedagogy and the other a content-expert to focus on content knowledge. Content to be addressed in the STAMPS professional development project focused on physical science content and topics were selected based on previous studies surrounding students’ misconceptions and teachers’ unpreparedness to teach these concepts (Jackson, Dukerich, & Hestenes, 2008; Jenkins, Birk, Bauer, Krause, & Pavelich, 2004).

This first half of STAMPS ran from July 22\textsuperscript{nd} through August 2\textsuperscript{nd}, 2013. During all day sessions from 8 am to 5 pm, teachers were led through the content by one of two teacher consultants who have extensive knowledge and experience in both content and modeling pedagogy. During these sessions, the teachers worked as their students would, in small groups, and then provided their findings to the facilitators and other teachers via graphs, pictures, and
written and verbal explanations. Week one of this summer professional development was
dedicated to physics content, while week two was dedicated to chemistry. Teachers were given a
copy of the modeling curriculum for both physics and chemistry on a flash drive as well as
supplies to be used in their classroom as they implemented this curriculum. During the second
half of the program, monthly academic year sessions, teachers were given an opportunity to
discuss the implementation and success of the modeling instruction in the classroom, and guided
through further content in chemistry or physics, alternating by session. Outside of the academic
year sessions, teachers remained in contact via an online discussion board (EDMODO) through
which they were able discuss any issues or success stories with the modeling curriculum that
occurred in their classroom.

**Purpose of the Study and Research Questions**

With knowledge that the United States falls significantly behind many countries in math
and science, I am curious to know why this is. It is clear through students’ declining
achievement in science that there is a critical need to improve math and science education (Glenn
Commission Report, 2000). It is therefore the aim of my research to answer the following key
research questions:

1. Is teachers’ physical science knowledge improved through STAMPS III professional
development?

2. Is student achievement in science improved through STAMPS III professional
development?

**Personal Interest**

During my experience as a graduate student in Chemistry, I often felt academically
behind my fellow classmates who were international students. I was one of only two American
students in my year in the program. Following this experience in graduate school, I became interested in a study that would provide some evidence as to why students in science education may not succeed. I participated in STAMPS III professional development myself, and used the modeling methods described in this thesis throughout my student teaching experience. It was my hope to evaluate the STAMPS project to see if it succeeds in its goals of improving both science pedagogy and content knowledge, as well as the effects this improved instruction may consequentially have on student achievement.

**Definition of Terms**

**Force Concept Inventory (FCI)** – multiple choice test developed to test common misconceptions regarding force and motion (Hestenes, Wells, & Swackhamer, 1992)

**Chemistry Concept Inventory (CCI)** – similar to the FCI, multiple choice test developed to test common misconceptions regarding chemistry (Jenkins, et al., 2004)

**Modeling instruction** – expresses an emphasis on the construction and application of conceptual models of physical phenomena as a central aspect of learning and doing science (Jackson, Dukerich, & Hestenes, 2008)

**Socratic questioning** - questioning is used in modeling to help probe student thinking to determine what students know and understand and to help students distinguish this from what they do not know and understand

**Summary**

In the following chapters, the literature, data and conclusions are summarized. Chapter two is a review of the current literature surrounding this research. Chapter two begins with a brief overview for the need for improvement in science education. Chapter two provides a detailed discussion of the previous research covering modeling instruction and professional
development workshops, as well as discusses the common misconceptions addressed through modeling instruction. Finally, chapter two covers several factors affecting improved science education including teacher attitudes and beliefs, pedagogy, and content knowledge. Chapter three presents a summary of the methodology and participants of this study, including demographic data and data analysis methods and software utilized. Chapter four provides an in depth analysis of the qualitative and quantitative data collected in this study. Finally, chapter five summarizes the data and findings, offers several conclusions for the context of the study within existing literature, and provides suggestions for future study.
CHAPTER TWO: REVIEW OF LITERATURE

Introduction

Recent research and statistics indicate the growing need for major improvement in science education (McWilliam, Poronnik, & Taylor, 2008). Wieman (2007) calls for a more scientific approach to teaching science, as there is a growing need for a more scientifically literate society to address global issues. Furthermore, science education researchers discuss “the growing call for student-centered, individualized learning approaches” (McWilliam et al., 2008, p. 10).

To improve student achievement it is necessary to improve teacher competence, as there is evidence that poor teaching may be one of the most influential factors in low test scores (de Souza-Barros & Elia, 1997 in Munck, 2007). Finally, Hestenes (2006) argues “science content cannot be separated from pedagogy” (p. 1). Many teachers and students hold misconceptions about basic science concepts. In order to improve student achievement, teachers’ understanding of these misconceptions must be improved so that they may help students understand these basic fundamental concepts.

Modeling Instruction

Research has shown that modeling instruction is one way to improve science education, by disconfirming misconceptions formed during the teaching of science concepts (Jackson, Dukerich, & Hestenes, 2008). Modeling Instruction is research-based science education reform that was funded by the National Science Foundation (NSF) from 1989 to 2005 and since then has been continued in many workshops across the nation, often funded by state funds. Modeling instruction, “expresses an emphasis on the construction and application of conceptual models of physical phenomena as a central aspect of learning and doing science,” (Jackson et al., 2008, p. 10). Essentially, modeling instruction is a guided inquiry approach to teaching science concepts.
The desired outcome of modeling instruction is students who are able to engage in discussion and debate about scientific concepts, and who are able to reason and defend their understanding. Deep conceptual understanding is at the core of modeling instruction, and as such, the traditional lecture-demonstration method is not followed (Jackson et al., 2008).

In modeling, rather than traditional units, content is organized into cycles (Jackson et al., 2008). Initially, students are presented with a demonstration and the teacher leads them through a discussion. This allows both the teacher and student to arrive at a common understanding and to pose a question of nature to be answered. Students then collaborate in groups to answer the question at hand by conducting experiments of their own design. Through probing questions, the teacher is able to help students develop their experiments and clarify their questions. Through this process students develop their own conceptual model for a physical phenomenon that they are then able to deploy and develop through future modeling cycles. Once students have carried out their experiments in small groups, they are given the opportunity to present and defend their findings through “white boarding” sessions in which they provide their data to the class on white boards pictorially, graphically, and through written explanations. This opens the class to further debate as both the teacher and other students are able to ask questions. Through participation in professional development modeling workshops “the teacher is equipped with a taxonomy of typical student misconceptions to be addressed as students are induced to articulate, analyze, and justify their personal beliefs” (Halloun and Hestenes, 1985b in Jackson et al., 2008, p. 12).

The modeling cycle begins with model development in which students are first presented with a pre-lab discussion, followed by a lab investigation and post lab discussion. The model is then deployed through worksheets and quizzes, lab practicum and unit tests provided in the modeling curriculum. Whereas in traditional instruction students are often lectured on a concept
and then given a set of instructions to follow while exploring the concept, modeling instruction focuses on students’ personal beliefs as they may influence learning (Jackson et al., 2008). It can be summarized, therefore, that in modeling instruction “instead of designing the course to address specific ‘naïve conceptions,’ the instructor focuses on helping students construct appropriate models to account for the phenomena they study” (Jackson et al., 2008, p.13).

**Professional development.** Research has also shown that workshops dedicated to teaching modeling instruction to educators have been effective in increasing student achievement (Wells, Hestenes & Swackhamer, 1995). “Modeling instruction places a strong emphasis on professional development, both during the workshops and afterward” (Jackson, et al., 2008, p. 14). First conducted in 1990, these professional development workshops have become popular across the country, with a growing body of proven success (Hake, 1998).

Through the professional development workshops teachers learn how to successfully implement a modeling curriculum. STAMPS I and STAMPS II showed that such professional development projects have been successful in achieving their goals

**Common Misconceptions in Science**

At the root of the problem in much of science education are common misconceptions on the part of both students and teachers. Even strong students and talented teachers can hold such misconceptions. Furthermore, these misconceptions are deeply rooted and difficult to identify and change. Keeley (2012) cites the very misunderstanding of the word misconception as one reason we as science educators struggle to effectively address them with students. More specifically, Keeley explains that not all misconceptions are the same, as “researchers often use labels such as alternative frameworks, naïve ideas, phenomenological primitives, children’s ideas, etc., to imply that these ideas are not completely ‘wrong’ in a students’ common-sense
world” (Keeley, 2012, p. 12). Furthermore, teachers may also feel that all misconceptions are major barriers to learning; however, “a conceptual misconception warrants greater attention than a trivial factual misconception” (Keeley, 2012, p. 12). It is therefore important that the word misconception is a general term that describes students’ scientifically inaccurate or partially accurate ideas, and therefore Keeley (2012) argues, “recognizing that the word misconception is a general way of referring to views students hold about the natural world that differ from conventional scientific explanations” (p.13) is critical to teachers’ understanding of misconceptions.

At the core of the modeling method of teaching is a deep conceptual understanding of key science ideas that physical science teachers must understand to be effective science teachers in order to improve student achievement. Assessments have been designed that seek to uncover these conceptual misunderstandings. The Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992) was designed with questions that require “a forced choice between Newtonian concepts and common sense alternatives” (p. 142). Newtonian concepts covered by this inventory include kinematics, Newton’s Laws, and forces. It is notable that the wrong answers on such inventories are commonsense beliefs held by many, and while false, are grounded in everyday experiences and, as such, should be treated “not as a test of intelligence, but a probe of belief systems” (Hestenes et al., 1992, p. 142).

Likewise, a large body of research surrounds misconceptions in chemistry and the Chemistry Concept Inventory (CCI; Jenkins, et al., 2004) is designed to address such misconceptions. Common misconceptions are held about matter, thermodynamics, stoichiometry and chemical bonding, among others (Kind, 2004). For example, many students do not have a conceptual understanding of the particulate nature of matter prior to high school,
because they do not need to. This in itself cannot be called a misconception as students have yet learned about this subject matter; however, Millar (1989) suggested that students do not use the particulate nature of matter because prior to the introduction of such abstract ideas at the high school level, students previous views of matter have not been questioned. Much like the misconceptions addressed by the FCI, concepts addressed by the CCI are those that many commonly misunderstand, and yet have a basic understanding of based on everyday experience.

Knowledge of misconceptions can influence a teachers’ planning and teaching. Once a teacher is aware of such misconceptions, they will need “to induce significant conceptual change, a well-designed and tested instructional method is essential” (Hestenes at al., 1992, p. 150). Modeling instruction is one such method, and has been well-designed and tested (Jackson et al., 2008; Hestenes, 2006). Through knowledge of students’ misconceptions as well as their own misconceptions, teachers can lead students in instruction and discourse that allows both parties to arrive at a deep conceptual understanding of the physical concepts of nature explored in physics and chemistry.

**Socratic Questioning**

Socratic questioning is often used in modeling and is defined by Paul and Elder (2007) as “disciplined questioning that can be used to pursue thought in many directions and for many purposes” (p. 36). Socratic questioning is used in modeling to help probe student thinking to determine what students know and understand and to help students distinguish this from what they do not know and understand, and furthermore, to help students begin to ask questions of their own (Paul & Elder, 2007).

There is a great deal of research which focuses on engaging students in scientific practices such as reasoning and discussion in order to promote argumentation in science (Clark...
& Sampson, 2008; Zohar & Nemet, 2002). Scientific inquiry has been described as “a knowledge-building process in which explanations are developed to make sense of data and then presented to a community of peers for critique, debate, and revision” (Clark & Sampson, 2008, p. 448). Many students will make claims and yet fail to support these claims with data or warrants. Chin and Osborne (2010) state that, “questions are a key component of discursive interaction in natural conversation and serve the function of challenging the views of the speaker or sustaining dialogue” (p. 884). Clark & Sampson (2008) further discuss that the three key components to students’ arguments in the contexts of science are the complexity of the argument, the content of the argument, and the nature of the justification. By asking questions, teachers are able to start and maintain a dialogue with their students, which allow students to arrive at conceptual understanding through teacher practices.

Factors Influencing Effective Practice

There are three important factors that influence effective practice of teachers. These include teachers’ attitude and beliefs toward teaching science, teachers’ pedagogy, and teachers’ content knowledge. Furthermore, modeling is unique in that it is also addresses pedagogical content knowledge, i.e. not only the content teachers’ must teach, but also how to teach these concepts.

Attitudes and beliefs. There is an obvious and increasing need for more competent and confident teachers in order to improve science education. Munck (2007) conducted a study linking science pedagogy, teacher attitudes, and student success. Previously, teachers’ attitudes about science teaching had been linked with lack of skill and knowledge (Shrigley, 1983). Munck (2007) found that contrary to previous studies, teacher attitude did not affect teaching pedagogy or student learning success. Two possible reasons for the lack of connection between
positive science teaching attitudes and student achievement is that “teachers may wish to present
themselves as positive pro-science teachers when they are not” and “teachers may have positive
attitudes about science teaching, but they do not have the pedagogical skills needed for inquiry-
based instruction” (Munck, 2007, p. 21). Motivation in any classroom is dependent upon the
attitude of the teacher. A study aimed at measuring the intrinsic motivation, vitality, and teacher
enthusiasm found, not surprisingly, that teacher enthusiasm is the most likely predictor of student
vitality and intrinsic motivation (Patrick, Hisley & Kemper, 2000).

A lack of confidence in teaching ability can also affect student motivation. When teachers
were partnered with research scientists to assess the participants’ attitudes about science and
science education, it was found that both teachers and scientists benefitted from this
collaboration (Czerniak & Belyukova, 2003). Ultimately, it was found that teachers who were
less familiar with or confident in their abilities to teach scientific inquiry benefited from working
with the scientists, and the scientists gained further insight into science education. However, it
was interesting to note that the results were most positive when teachers and scientists were
treated as equal partners.

From the results of these studies it is obvious that teacher attitude is crucial to the success
of the classroom. When teaching children who may be lower tracked, socioeconomically
disadvantaged, or with special learning needs, it is important that the teacher recognize and
respect these students differences, while being confident in their ability to help the student, all
while continuing positive encouragement towards the students’ abilities.

**Pedagogy.** In a 1995 report, The American Association for the Advancement of Science
(AAAS) (1995) set forth several suggestions for change in science pedagogy, emphasizing that
science literacy depends on a pedagogy that is consistent with the very nature of science and the
need for inquiry based pedagogy is clear. Specifically, science pedagogy should include an questions first, answers later approach. Students should arrive at answers through use of hypotheses and collection of evidence, consistent with the modeling instruction approach (AAAS, 1995). Furthermore, the National Science Education Standards (NSES) also emphasize the need for inquiry based learning and collaboration in science (Munck, 2007; NRC, 1996). “An increasing body of research strongly links low student test scores to poor teaching, some to the extreme that the single most influential factor, next to parental involvement, in student success is the teacher” (de Souza-Barros & Elia, 1997).

There are several pedagogies in science that lead to effective and engaging instruction, including inquiry, problem-based learning, process-oriented learning, and peer-led team learning (Eberlein, Kampmeier, Minderhout, Moog, Platt, Varma-Nelson, & White, 2008). Within modeling, inquiry learning is evident in the structure of lessons. Students are not given a set of directions or lectured on a topic, but rather are presented with a problem, and then allowed to explore this problem on their own. Following this exploration phase students then work in groups and through white boarding and Socratic questions arrive at a new and deeper understanding of content.

Therefore, “the attention of educational reform is now focused on quality teaching as much as on curriculum to improve education in areas in which quality science teaching is linked to both content knowledge and pedagogy proficiency” (Munck, 2007, p. 13). Teachers’ content knowledge is therefore as important as pedagogical practices.

**Content knowledge.** Teachers’ content knowledge has been the focus of much research within modeling and modeling has proven to be an effective method of instruction at the high school level. The Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992) and
the Chemistry Concept Inventory (CCI; Jenkings, et al., 2004) are commonly used in modeling workshops. Both of these assessments are research-based multiple-choice tests designed to assess common misconceptions about forces and motion in chemistry, respectively. In a survey of over 20,000 students, Hestenes et al. (1992) found that students score about 26% on the FCI, only slightly higher than the 20% that would result from random guessing. Furthermore, following traditional instruction (including lectures, demonstrations and standard lab activities), these students still only scored about 42%. Teachers who used modeling instruction, however, found that their students had a net gain in content knowledge almost three times higher including students who may not have previously had success with physics (Jackson et al., 2008). In addition to student improvement, teachers’ content knowledge is also significantly increased through modeling instruction, based on FCI and other assessment scores (Andrews et al., 2003).

**Pedagogical content knowledge.** Pedagogical content knowledge (PCK) considers that beyond the content knowledge of a teachers’ specific subject, teachers also have a sense of how to teach their content in a manner that increases student understanding (Loughran, Berry, & Mullhall, 2012). Shulman (1986) described pedagogical content knowledge as knowledge “which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching” (p. 9). There is a substantial amount of research as to the importance of PCK in teaching science. Teachers undoubtedly must have a rich conceptual understanding of the content they teach, such as that developed in modeling, and such an understanding “combined with expertise in developing, using and adapting teaching procedures, strategies and approaches for use in particular classes, is purposefully linked to create the amalgam of knowledge of content and pedagogy that Shulman (1986, 1987) described as PCK.” (Loughran et al., 2012).
**Student Motivation and Attitude**

As important as teacher attitudes and beliefs, there are several key factors that affect student achievement, including student motivation and student attitude.

**Motivation.** Of growing interest is the motivation of students in a science course. Pintrich and Schunk (2002) define motivation as “the process whereby goal-directed activity is instigated and sustained” (p. 405). It has been suggested that one cause of poor motivation and academic expectations in students are the differences teachers place on students in lower tracked courses versus those in higher tracked courses (Hallam & Ireson, 2003). Pickens and Eick (2009) cite Oakes (2005) in his assertion that there is a hidden agenda in schools that encourages lower performing students to “conform, work quietly, and get along with their peers while teachers proceed more slowly and cover less of the curriculum” (p. 349). Furthering this discrepancy, it is thought that teachers in higher tracks are more enthusiastic, spend more time preparing, and are judged as more successful (Vanfossen, Jones, & Spade, 1987).

There is evidence, however, that such motivation is science may not be inevitable. A study by Simpson and Oliver (1990) noted that the science curriculum and teaching practices used by teachers at that time were not producing students with positive feelings toward science. Furthermore, many studies cited by Vedder-Weiss and Fortus (2010) note that the decline in motivation and positive feelings toward science usually occurs at the secondary school level. Achievement Goal Theory has been a major focus of research in this field, and it has been found that in the field of science education “mastery goals in science learning has a positive relation with desired learning characteristic and therefore should be encouraged and fostered by parents, teachers and schools” (Vedder-Weiss & Fortus, 2010, p. 200).
Summary

There is an apparent and growing need for improved math and science instruction through improved pedagogy and content knowledge. Modeling instruction first developed at Arizona State University has proven to be effective in improving science education through student concept inventory scores (Wells et al., 2005; Hake, 1998). Modeling instruction places a heavy emphasis on the importance of professional development in improving teacher content knowledge and pedagogy (Jackson et al., 2008). Modeling instruction addresses misconceptions in physics and chemistry that have been researched and found to be common among high school students. Unlike traditional instruction, modeling instruction involves the development and deployment of a model designed to provide students with a deeper understanding of natural phenomena. The use of Socratic questioning is essential to modeling instruction in that it provides teacher and student with an opportunity for discourse throughout the development of the model.

The importance of the teacher has been extensively researched as well. Student achievement has been linked with teachers’ attitudes and beliefs, as well as content knowledge. Pedagogical content knowledge, first introduced by Shulman (1986) further emphasizes the need for teacher expertise not only in subject content, but also in knowledge of how to teach a specific topic or concept. Other concepts such as parental support and socioeconomic factors but also be considered when measuring student achievement.

This study seeks to reinforce the current research and provide evidence for a significant relationship between modeling instruction and teachers’ content knowledge. This study also considers the relationship between a modeling professional development program and teachers’ content knowledge and beliefs and attitudes.
CHAPTER THREE: RESEARCH AND METHODOLOGY

Introduction

Research was conducted in coordination with the STAMPS (Science Teaching Advancement through Modeling Physical Science) professional development project from July 2013 through June 2014. Participants included 40 physical science and biology teachers from Northwest Ohio school districts. STAMPS provided teacher participants with an extended and active professional development opportunity. Through the STAMPS program teachers received 104 hours of professional development – 80 hours in the summer, and 24 hours during the school year. During the two-week summer workshop teachers were provided with the instruction and tools necessary to deepen their content knowledge and were provided with time to build their confidence to use modeling instructional practices effectively in their classroom. Week one of this summer workshop was devoted to physics content, while week two was devoted to chemistry. During the monthly academic year sessions, teachers were given an opportunity to discuss the implementation and success of the modeling instruction in their classroom, and guided through further content in chemistry or physics, alternating by session. During these sessions, the teachers worked as their students would, in small groups, and then provided their findings to the facilitators and other teachers via graphs, pictures, and written and verbal explanations.

Participants

Forty teachers participated in the STAMPS III professional development. A subset of these teachers were participating in the program for the first time and they are the focus of this research. In this subset, there were 23 high school teachers, 8 males and 15 females from Northwest and Central Ohio. These teachers taught Physics, Chemistry, Biology, and/or Physical Science courses. The teachers represented 18 different schools and ranged from no
teaching experience to 40 years of teaching experience, with an average of 11.7 years. Teacher demographics are summarized in Table 1, below. Demographics for students served by all teachers participating in the STAMPS III program are summarized in Table 2. Teachers in the STAMPS program recruited teachers within their school who used a traditional instructional method to provide a control group of students, and demographics are similar to that of STAMPS students.

Table 1

*STAMPS Teacher Demographic Information*

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Variable Category</th>
<th># and % of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>15 (65%)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>8 (35%)</td>
</tr>
<tr>
<td>Teaching Experience</td>
<td>1 to 5 years</td>
<td>6 (26%)</td>
</tr>
<tr>
<td></td>
<td>6 to 10 years</td>
<td>6 (26%)</td>
</tr>
<tr>
<td></td>
<td>11 to 15 years</td>
<td>4 (18%)</td>
</tr>
<tr>
<td></td>
<td>16 to 20 years</td>
<td>2 (8%)</td>
</tr>
<tr>
<td></td>
<td>21 to 25 years</td>
<td>3 (14%)</td>
</tr>
<tr>
<td></td>
<td>26 to 30 years</td>
<td>1 (4%)</td>
</tr>
<tr>
<td></td>
<td>35 to 40 years</td>
<td>1 (4%)</td>
</tr>
</tbody>
</table>
Table 2

*STAMPS Student Demographic Information*

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th># and % of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Needs (Economically Disadvantaged)</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>894 (26%)</td>
</tr>
<tr>
<td>No</td>
<td>2,527 (74%)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>2,802 (82%)</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>273 (8%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>193 (6%)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>84 (2%)</td>
</tr>
<tr>
<td>American Indian/Alaskan</td>
<td>3 (&lt;1%)</td>
</tr>
<tr>
<td>Native</td>
<td>66 (2%)</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td><strong>School Location</strong></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>184 (5%)</td>
</tr>
<tr>
<td>Suburban</td>
<td>2350 (7%)</td>
</tr>
<tr>
<td>Rural</td>
<td>857 (3%)</td>
</tr>
<tr>
<td><strong>Special Needs</strong></td>
<td></td>
</tr>
<tr>
<td>Limited English Proficient</td>
<td>62 (2%)</td>
</tr>
<tr>
<td>Disabled/Handicapped</td>
<td>175 (5%)</td>
</tr>
<tr>
<td>Migrant</td>
<td>91 (3%)</td>
</tr>
<tr>
<td>Gifted and Talented</td>
<td>212 (6%)</td>
</tr>
</tbody>
</table>

**Evaluation and Instrumentation**

A mixed methods approach was used in this study as both qualitative and quantitative data were collected throughout the STAMPS project. Mixed-methods research is described as
an approach to inquiry different from research that is conceived of as mono-method research, or as exclusively qualitative or quantitative” (Sandelowski, 2014, p. 3). There are several types of mixed methods research explained in literature on the subject, but here a linked type of mixed methods approach is used, wherein the qualitative data is linked with quantitative data to provide support and evidence, but the two are not merged (Sandelowski, 2014).

Within this study, quantitative data include student and teacher scores on a concept inventory (CI). A different concept inventory was used to measure student and teacher content knowledge, and an explanation of each instrument is provided below. The Perceptions of Science Teaching Practices (P-Step) survey was used to measure teachers’ attitudes and beliefs towards teaching science. This quantitative data was analyzed for significant relationships between the STAMPS III professional development program and student and teacher content knowledge, as well as teacher attitudes and beliefs.

Qualitative data includes eight teacher observations as well as open-ended questions to teachers on a post-project questionnaire. Qualitative data was used only to reinforce significant conclusions made by quantitative data.

**Quantitative data.** Teachers’ content knowledge was measured using the Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992) and the Chemistry Concept Inventory (CCI; Jenkins, Birk, Bauer, Krause, & Pavelich, 2004). The FCI consists of 27 multiple choice questions designed to force a “choice between Newtonian concepts and common sense alternatives” (Hestenes et al., 1992). Likewise, the CCI consists of 28 multiple-choice questions. These are commonly used and reliable instruments in modeling workshops, with a reliability of $\alpha > .7$ (Hestenes et al., 1992; Jenkins et al., 2004), and both are research-based multiple-choice
tests designed to assess common misconceptions about forces and motion and chemistry, respectively.

Students’ understanding of science concepts was assessed using a Physics assessment comprised of items taken from the American Association for the Advancement of Science (AAAS), and the Assessment of Basic Chemistry Concepts (ABCC). Teachers administered their own assessments and reported the average score data for their students.

**Qualitative data.** Qualitative data collected throughout STAMPS included teacher observations, evidence of discussion on the online data base, and follow up questions regarding the benefits of the workshop. An observation protocol was developed by the STAMPS co-investigators and is provided in Appendix A. Analysis of observations and follow up questions was combined by searching for key ideas throughout the observations and in responses to follow up questions that serve as further evidence to quantitative data.

**Data Analysis**

**Quantitative analysis.** The data were analyzed using JMP 11.1.1 software (SAS, Institute Inc., Cary, NC). A one way repeated measures ANOVA (analysis of variance) test was used to analyze the data and to determine if teachers’ chemistry and physics content knowledge changed significantly through the course of the workshop and throughout the academic year. ANOVA analyses can be described as “separation of the variance ascribable to one group of causes from the variance ascribable to other groups” (Fisher, 1925, p. 216). A repeated measures ANOVA test is appropriate when comparing related means across various time intervals. Twenty-three teachers completed both the pre and post-workshop assessment, while only 15 teachers completed the post-academic year physics and chemistry assessments. Only teachers
who completed the assessments at all three time intervals could be included in the analyses as repeated measures ANOVA require.

**Qualitative analysis.** The classroom observations conducted and post-reflection teacher responses were analyzed for common themes and responses and excerpts are provided in narrative form. “The main function of reporting general descriptive data is to establish the generalizability of patterns that were illustrated in particular description though analytic narrative vignettes and direct quotes” (Erickson, 1985, p. 151). Qualitative data from teacher observations and a post project survey was therefore used to reinforce patterns seen in quantitative data.

**Limitations of the Study**

This study was limited by several factors. At the time of data analysis, a smaller portion of post tests were received than pre tests. Therefore, not all student data could be analyzed for the purpose of this study. Furthermore, the teachers in this study had a varied content background and years of teaching experience. Only generalized conclusions can be made across the success of students in classes taught by teachers with varying teaching ability.

**Summary**

Teachers were recruited to the STAMPS professional development project in the Spring of 2013. The workshop itself took place in July of 2013 with 80 contact hours, followed by 3 contact hours through 6 academic year sessions. During the workshop, teachers were led through modeling instruction and participated in both student and teacher mode. Teacher mode allowed teachers to talk clarifying questions and raise any opinions they may have on the content being learned throughout the lesson at hand. Teachers were administered a physics and chemistry concept test at the start of the workshop, immediately following the workshop, and following the academic year sessions. To test student content knowledge, students administered their own pre
and post tests to their students in chemistry, physics, or physical science as appropriate to the class they were instructing. STAMPS teachers recruited control group teachers by having several colleagues who currently use traditional instruction to also administer these pre and posttests at a similar time interval.
CHAPTER FOUR: DATA SUMMARY AND ANALYSIS

The intention of this research was to analyze the effect the STAMPS professional development had on teacher and student content knowledge. Specifically, this study sought to answer three key research questions:

1. Is teachers’ physical science knowledge improved through STAMPS III professional development?
2. Is student achievement in science improved through STAMPS III professional development?

In this chapter the data of this study is presented, as well as an analysis and discussion of the findings of this study. Findings are organized by both research question and control group versus STAMPS group.

Effect of STAMPS workshop on Teachers’ Content Knowledge, Beliefs and Attitudes

Quantitative data summary. Teacher data was inspected for normality. Results of the ANOVA analyses indicated a statistically significant increase in teachers’ Physics content knowledge, $F(2,28) = 6.004, p < .01$, partial $\eta^2 = .300$. Mauchly’s Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 3.152, p = .207$, indicating an equal variance between the tests at each time interval. Likewise, for the chemistry assessment, Mauchly’s Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 1.951, p = .377$. Results of the repeated measures ANOVA indicated a statistically significant change in the means of teachers scores on the chemistry assessment, $F(2,18) = 3.506, p < .05$, partial $\eta^2 = .200$. However, while teachers’ chemistry content knowledge initially increased, the post assessment scores were lower than both pre- and post-workshop scores. Further analysis did not indicate a significant increase between pre-workshop and post-workshop
scores, and there was no statistically significant decrease between pre-workshop and post-academic year scores. Table 2 and Figure 1 summarize the data.

Table 3

Summary of the Effect of STAMPS on Teachers’ Content Knowledge

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Pre-Workshop</th>
<th>Post-Workshop</th>
<th>Post-AY</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>19.67 (7.24)</td>
<td>22.93 (5.20)</td>
<td>22.47 (5.37)</td>
<td>6.00**</td>
</tr>
<tr>
<td>Chemistry</td>
<td>23.33 (4.86)</td>
<td>24.86 (3.62)</td>
<td>22.93 (4.27)</td>
<td>3.51*</td>
</tr>
</tbody>
</table>

n=15

*p < .05, ** p < .01, ***p < .001

Figure 1. Pre-workshop, post-workshop, and post-AY teachers’ mean score for physics and chemistry assessments.
Effect of STAMPS Workshop on Student Achievement

**Quantitative data collected.** To determine the effect of modeling instruction on student content knowledge, students were administered a pre and post concept test. Teachers administered their own pre and post tests and students provided a unique code so that pre and post test data could be matched together while not identifying the student. Only students who completed both a pre and posttest were considered valid and included in the data pool.

**Chemistry.** Students in the control group and STAMPS group indicated a significant increase in Chemistry content knowledge. Two-way ANOVA analysis indicated a statistically significant interaction between time and student group (F, [1,173] = 10.361, p < .001). Figure 2 below summarizes the data.

**Physics.** Students in the control group and STAMPS group indicated a significant increase in Physics content knowledge. Two-way ANOVA analysis indicated a statistically significant interaction between time and student group (F[1,244] = 16.100, p < .0005). Figure 3 below summarizes the data.

**Physical science – chemistry.** ANOVA analysis did not indicate a statistically significant interaction between time and student group for the physical science chemistry content (F[1,180] = 10.297, p < .01), meaning that students in the control group and STAMPS group had similar gains in knowledge over the academic year.

**Physical science – physics.** ANOVA analysis did not indicate a statistically significant interaction between time and student group for the physical science physics content (F[1,173] = 3.428, p > .05), meaning that students in the control group and STAMPS group had similar gains in knowledge over the academic year.
Figure 2. Chemistry content knowledge. Mean scores for students in STAMPS and control group, pre and post test results.

Figure 3. Physics content knowledge. Mean scores for students in STAMPS and control group, pre and post test results.
Figure 4. Physical science – chemistry content knowledge. Mean scores for students in STAMPS and control group, pre and post test results.

Figure 5. Physical science – physics content knowledge. Mean scores for students in STAMPS and control group, pre and post test results.
Qualitative data collected. Following the professional development project, STAMPS III teachers answered several open ended questions regarding the impact it had on their teaching. Teachers were asked to describe their personal experience with the project. One teacher noted that “This experience gave me a lot of personal background and better understanding of the topics I teach. I also gained great incite to effectively incorporating inquiry learning into my classroom. I have better respect to the ability of my students and their effort, while another responded that, “I learned a much better way to teach science. I have a deeper understanding of my content area.” Such responses support quantitative data indicating that teachers’ beliefs and attitudes towards teaching science changed throughout the project. Such improvements are further supported by teacher comments that through the program it became “easier to see students’ misconceptions.”

Teachers were also asked “What have you learned since implementing Modeling Curriculum and pedagogy into your classroom setting with your students?” Further supporting data that teachers were better able to identify and address students’ misconceptions, one teacher noted “I have learned what truly students know and don’t know. The modeling approach reveals numbers misconceptions students hold or this misunderstanding so that I can differentiate my questioning and assess on the spot.” Responses to this question also supported a change in teacher attitude and belief with responses including, “It is hard work to be an effective teacher. You need to understand the topics you teach so that the students see the model that you’re trying to get them to develop and “I have learned that students need to experience concepts before they can understand and apply them.” Lastly, teachers were asked “What has changed about your students’ performance and involvement as a result of your participation in Project STAMPS?” While quantitative results of the assessments showed a statistically significant increase in
students’ content knowledge, teachers’ responses to this question further supported the data. One teacher responded “I think my students “get the concepts better after teaching the modeling process. They don’t just get the ‘right answer’ but get the overall concept and can better explain it.” Other teachers added that “my students no longer memorize ideas and equations—they now engage in scientific discourse and an exchange of ideas and concepts” and that “my students are more actively involved in the learning process and their overall performance on tests/assessments has increased.”

**Teacher observations.** Teacher observations conducted using an observation protocol also indicate that teachers effectively implemented modeling instruction to address student misconceptions and improve student content knowledge. In one class, two teachers were observed as co-teachers in which they were teaching a class on density, a topic surrounded by many misconceptions. In this lesson, when students presented their whiteboards to the class and remarked that one object had more weight, through Socratic questions they were lead to conclude that one object had more mass, rather than weight. Students were asked what they had written down as the definition of volume and correctly answered “the amount of space something takes up.” Throughout this lesson students were able to correctly define mass and volume and to identify density as the ratio between mass and volume.

Another lesson focused on force diagrams and also addressed several common student misconceptions. Students were first shown a demonstration in which a car was first standing still on a track, and then a second demonstration in which a car was moving down a track. Students were then asked to draw a picture of the car both standing still and moving, and to identify the forces acting on the car. When a student mentioned gravity as one force acting on the car, this
lead to a rich discussion of the direction of the force of gravity, and served as an introduction to force and motion diagrams.

In all of the lessons that were observed, it was clear that teachers had a great deal of confidence in teaching the material. Additionally, many of the students exhibited a clear confidence in the content with one student remarking “I am actually pretty good at this!”

**Personal experience.** Throughout the STAMPS professional development program, I actively participated in the activities and discussions. Throughout the summer workshop and over the academic year sessions, I found my own content knowledge and confidence in my abilities challenged, and yet I felt that at the conclusion of the program my ability to effectively teach science increased immensely. This sentiment was expressed by my colleagues in the program and on several occasions it was stated that participants wish they had learned science in the way it is presented in the modeling curriculum, as it would have better prepared them to teach science in the classroom.

**Summary**

Data analysis indicated a statistically significant improvement in teachers’ physics content knowledge, while teachers’ Chemistry content knowledge initially increased and later decreased and was not statistically significant. Students’ content knowledge increased significantly over time in chemistry, physical and chemistry physical content knowledge, indicated that STAMPS students significantly increased their knowledge in this content over the school year. While there was no significant gain in the STAMPS group compared with the control group over time for physical science physics content knowledge, students in both groups significantly increased their content knowledge over time.
CHAPTER FIVE: CONCLUSIONS

This study sought to answer three research questions: “Is teachers’ physical science knowledge improved through STAMPS III professional development?” “How are teachers’ attitudes and beliefs towards teaching science changed through participation in the STAMPS III professional development?” and “Is student achievement in science improved through STAMPS III professional development. Conclusions are presented here summarized by research questions, and several recommendations for future student follow.

Research Question 1

The first purpose of this study was to research the effects of the STAMPS workshop on teachers’ science content knowledge. While teachers showed significant gains in their physics content knowledge, they did not show significant gains in their chemistry content knowledge, and scores on the chemistry assessment following the workshop and academic year sessions showed a slight though not significant decrease in chemistry content knowledge. Teachers’ initial scores on the chemistry assessment were very high, so a significant increase would not be expected.

Teacher observations and follow up questions support these conclusions. Teachers indicated that following involvement in the STAMPS professional development teachers had a better understanding of what their students did and did not know, with several participants indicating that they had a better understanding of the topics they teach following the workshop. One participant even noted “I have a deeper understanding of my content area.”

Research Question 2

The final purpose of this study was to examine the effect of teachers’ involvement in the STAMPS III workshop on students’ content knowledge. While teachers showed a high level of content knowledge prior to participation in this professional development, they did not show a
significant gain in content knowledge in chemistry while their students did show a significant
gain in chemistry content knowledge. Overall, students showed significant gains in content
knowledge in both chemistry and physics, but did not show significant gains in physical science
content knowledge. These results are similar to the results seen in STAMPS I and II. The
modeling curriculum was initially developed for physics and chemistry content, and has been
adapted as a physical science curriculum but STAMPS teachers.

Evidence collected through the teacher survey and classroom observations indicate that
this improvement in student achievement is due to effective implementation of modeling
instruction and improved teacher attitude, as evidenced in the P-STeP results. Following up
questions following the program indicated that teachers felt they had gained a better ability to
identify student misconceptions and to address these misconceptions through improved
instruction, leading students to perform better on tests, quizzes, and assessments in class. Data
collected also suggests that the significant gains made by students in the STAMPS group as
compared to the control group is related to improved teacher attitudes and beliefs as a result of
participation in the STAMPS III program.

**Recommendations**

It is promising to see the continued improvement in teacher and student content
knowledge. Teachers who have participated in STAMPS III report both a change in attitudes and
beliefs as well as content knowledge. Administrators seeking to improve science education
should encourage participation of science teachers in this and similar professional development
workshops. STAMPS IV will be implemented from July 2014 through June 2015. It is clear
from the results of STAMPS III that the physical science curriculum must be improved in order
to see gains in student content knowledge. As stated previously, the modeling curriculum was
initially developed for chemistry and physics and is often modified by teachers to fit the needs and standards of physical science students. Close collaboration among the teachers in STAMPS and the professional development coordinators would help to strengthen and polish this curriculum so that similar gains are seen for these students.

Finally, the teachers involved in this study had a varied level of teaching experience, and it is unclear if the gains made by students are the result of improved teacher content knowledge, modeling instruction, or simply experienced teachers. A more controlled study in which teachers are more closely matched in teaching experience and content area may help in evaluating if the gains made by students are due to modeling instruction or other factors.

It is possible that the significant gains made in content knowledge by students in the STAMPS group are due to factors beyond improved teacher content knowledge. While teacher content knowledge is notably important, other factors can also affect student achievement. It is possible students also benefit from improved teacher attitudes and beliefs, and this may affect student motivation. Future studies as to how modeling instruction has an effect on student motivation and attitude toward science may offer insight into the benefits a modeling workshop such as STAMPS has on student content knowledge.

**Summary**

Analyses of the physics and chemistry assessments administered to teachers showed a statistically significant increase in physics content knowledge, but no significant increase in chemistry content knowledge. The lack of improvement in chemistry content knowledge can be attributed to teachers initially scoring very high on the ABCC. P-STeP analyses indicated that teachers significantly increased in their beliefs regarding self-efficacy in teaching science as well as their confidence in using reform-based teaching practices. Students showed a significant
increase in their content knowledge for physics and chemistry due to improved teacher pedagogy, as evidenced in the qualitative data collected throughout this study. STAMPS I and STAMPS II provided similar results, and continued studies will help to reinforce the conclusions made here.
REFERENCES


http://psychclassics.yorku.ca/Fisher/Methods/chap6.htm


Kind, V. (2004). *Beyond appearances: Students’ misconceptions about basic chemical ideas*. 2nd ed. Durham University: School of Education.


APPENDIX A: OBSERVATION PROTOCOL

<table>
<thead>
<tr>
<th>OBSERVATION POINT/REFERENCE</th>
<th>Description of what was observed during the lesson. Remember, not all fields will be observed during each lesson, but all are key components of the Modeling curriculum and instruction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students/ Materials</td>
<td></td>
</tr>
<tr>
<td>Science materials actively used by students and teacher</td>
<td></td>
</tr>
<tr>
<td>Teachers use modeling lesson plans with or without modification</td>
<td></td>
</tr>
<tr>
<td>Model development through laboratory activity</td>
<td></td>
</tr>
<tr>
<td>Model development through mathematical discovery</td>
<td></td>
</tr>
<tr>
<td>Model development through discussion (white boarding sessions/Socratic questioning)</td>
<td></td>
</tr>
<tr>
<td>Students work cooperatively on model development</td>
<td></td>
</tr>
<tr>
<td>Students Drawing/Modeling representations of the concepts</td>
<td></td>
</tr>
<tr>
<td>Students summarize key ideas verbally or by drawing/writing</td>
<td></td>
</tr>
<tr>
<td>OBSERVATION TEACHER</td>
<td>Description of what was observed during the lesson.</td>
</tr>
<tr>
<td>Confident using the materials</td>
<td></td>
</tr>
<tr>
<td>Confident teaching the content</td>
<td></td>
</tr>
<tr>
<td>Confident checking for student understanding through questioning</td>
<td></td>
</tr>
<tr>
<td>Confident using modeling techniques (labs/white boards, mathematics)</td>
<td></td>
</tr>
<tr>
<td>Confident using modeling curriculum</td>
<td></td>
</tr>
</tbody>
</table>
Other Notes or Comments on Lesson
Teacher Participant Informed Consent

You are invited to participate in a research study designed to investigate the effectiveness of a professional development program called Project STAMPS (Science Teaching Advancement through Modeling Physical Science). The Principal Investigator of this project is Dr. Tracy Huziak-Clark, a faculty member in the School of Teaching of Learning. The purpose of Project STAMPS is to: 1) provide you with opportunities to improve your knowledge of physical science content and teaching strategies, and 2) provide you with educational resources to assist your teaching pedagogy and to support your use of modeling as a teaching method. As a result, we hope to improve student knowledge and attitudes about science.

You will be requested to participate in several evaluation activities during this project. These activities will include: completing surveys and content knowledge tests, being observed in your classroom, and giving your students content tests and attitude surveys. We estimate your participation in this study will take approximately one year. The anticipated risks to you are no greater than those normally encountered in daily life. This project will provide you with professional development activities that may improve your science knowledge, provide you with effective teaching resources, and increase your confidence in teaching science.

You are under no obligation to release your evaluation data for this research project; your decision to allow us to include your information is entirely voluntary.

If you agree to allow us to use your data for research, you will provide us with your name and unique identification code on the included form. This will allow us to match your survey or test responses to other data sources you may provide during this project (i.e., observations, content tests, etc.). While providing your name means that your information will not be anonymous, we have incorporated a number of safeguards in the processing and reporting of your information in order to maintain your confidentiality. These safeguards include returning your evaluation data directly to the evaluation team, keeping your data locked in the evaluator’s office, not allowing access to persons other than the project staff, and reporting the data in summary (i.e., by grade level and/or content area). Also, for most evaluation activities (i.e., surveys and tests), you will be asked only to provide your unique code, which will be used during the analysis of those data. Your name will not be matched to your code unless it is absolutely necessary for the evaluation of the project. For example, if you were to write your name, instead of your code, on a piece of evaluation, we would have to consult the consent form to be able to match that piece of evaluation with the others you already completed. The only exception is the collection of the required Ohio Board of Regents (ORB) survey that must be completed at the beginning and end of grant. This survey data is reported to the state so that they may document the number of teachers and students impacted by the grant.

Your participation in this research is very important to understanding the impact of Project STAMPS and identifying ways to improve science education. If you agree to participate in this research study, please write your unique code and print and sign your name on the appropriate line on included form and return it to the evaluator. If you do not wish to participate, please write your unique code and print your name on the appropriate line on included form and return it to the evaluator. Providing us with your information will ensure that we do not use your responses in our data analyses. You may refuse to participate in this investigation or withdraw your consent and discontinue participation in this study without penalty and without affecting your relationship to the university, the project staff, or your school. By agreeing to participate, you give us permission to use your responses in the research of this program. Please keep this letter and retain it for your records.

If you have questions concerning the evaluation, please contact the Principal Investigator Tracy Huziak-Clark at 419-372-7363 (thuziak@bgsu.edu). If you have questions about the conduct of this study or your rights as a research participant, you may contact the Chair of Bowling Green State University’s Human Subjects Review Board at 419-372-7716 (hsrb@bgsu.edu).
Teacher Participant Informed Consent

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE IN THIS RESEARCH STUDY HAVING READ THE INFORMATION PROVIDED ABOVE, AND BASED ON THE FACT THAT ALL OF YOUR QUESTIONS HAVE BEEN ADDRESSED TO YOUR SATISFACTION. THE INFORMATION OBTAINED FROM YOUR INVOLVEMENT IN THIS PROJECT WILL BE USED FOR ANALYSIS IN THIS STUDY.

Unique Code | Project | First 2 Letters of Mother’s Maiden Name | Your Birth Month (2 digits) | Your Birth Day (2 digits)
-------------|---------|--------------------------------------|---------------------------|---------------------
EXAMPLE      | S       | D E                                  | 0 7                       | 1 8                 
YOUR ID      | S       |                                      |                           |                     

Project S = STAMPS

1 **AGREE** to participate in this study.

Participant’s name (print): __________________________

Participant’s signature: _____________________________

Date: __________________________

1 **DO NOT** wish to participate in this study.

Participant’s name (print): __________________________

Date: __________________________