A condensation of
Modeling Instruction in High School Science: The Role of School Leadership
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Preface from Jane Jackson (Arizona State University, Dept. of Physics, Sept. 2018):
I made this condensed version of Mike Thomas' dissertation, with Mike's permission. It focuses on effective high school leadership for science – specifically, how a high school incorporated Modeling Instruction in all sciences. This outstanding work vastly adds to our knowledge of effective high school leadership for science.

Intended readership: high school science department chairs and science teachers; principals and vice-principals; K-12 policy makers. *Teachers: please share this with administrators.*

I made this condensation because effective school leadership for science education is crucial in the 21st century, where we face looming societal challenges that require reasoning skills that high-quality science instruction can provide. We must raise a populace of THINKERS. Modeling Instruction does this.

Since Mike's dissertation is long, this shorter version is an attempt to increase the number of people who read it. I hope that this helps high school leadership to improve, nationwide.

Advice for readers:
* Teachers who use Modeling Instruction can skip to chapter 5 (page 54). The one-page section called "Implications for Administration" (on page 66) sums it up.
* School leaders and policy makers should read chapters 4 and 5, at minimum.
* School administrators and policy makers who have limited science education experience should also read chapter 2, on science methodology and pedagogy.

Mike's research greatly adds to a document that I compiled and posted over many years, at http://modeling.asu.edu/Success/SchoolDistrMWs_JStankevitz.htm

This condensed version is posted at http://modeling.asu.edu/Projects-Resources.html
Contact Michael Thomas at mthomas@evergreenpark.org for his complete dissertation.

Abstract

Science education has undergone multiple reforms over the years, yet each reform continues to produce little change in student success. The latest reform of the standards — Next Generation Science Standards (NGSS) — look to change that trend by focusing on what students can do, rather than just what they know.

Modeling Instruction (MI) is one research-based pedagogy that is in alignment with the NGSS concepts of student-led classroom instruction. This proven strategy has been used across the U.S., but often in isolation, rather than as the routine classroom instruction throughout a school's science department.

Changes in new teaching methods, such as those needed to implement MI or NGSS, are not easy for schools to make. They require entire organizations to shift their beliefs in how education appears, with students actively working and presenting content, while the teacher walks to the students, facilitating and asking questions. Leadership within the school can help this transition take place, by providing structures and processes that support others attempting to make changes in their practice. Effective leaders not only provide a plan, but they also create a supportive climate in which goals can be achieved.

This qualitative case study looked at the leadership of schools that have implemented MI across the science curriculum, which includes Biology, Chemistry, and Physics. Characteristics of the leaders, such as leadership style and structures, provided information on how to make a successful change in instruction. Data was collected via interviews with school leaders and school faculty, and observations taken at the school. This data was then coded to identify common themes and trends.

Results of this research showed that leadership played an important role in the implementation of MI in secondary science classrooms. Key attributes were provided by school leadership to help with the implementation. Professional development provided the staff with the tools needed to learn the techniques of the new methods. Time for collaboration was also given, which allowed the staff to help each other with any problems that had arisen along the way. Finally, support was given by the leadership when teaching staff had problems with their implementation. These characteristics allowed for the change from traditional instruction to MI at two high schools, while minimizing problems and creating an atmosphere that inspired creativity.

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Acknowledgements

My journey in education, much like my journey in life, has been shaped by the impact of some incredible people of whom I would like to thank for their support along the way. First, I would like to thank my Michigan (mostly) family; they include my parents, aunts, uncles, and brother who have always pushed me to try new things, encouraged education, and given me unconditional support at the times when I needed it the most. I would also like to thank my Illinois family, which is comprised of mostly my wife's family, and includes friends and colleagues who have also expanded and refined who I am as a person, and again supported me through this process. Most importantly out of this group, I would like to send a special thank you to my loving wife, Lauren, and my beautiful daughter, Zoe. These two have gone above and beyond giving me all the little things I have needed to finish this project. That included taking on extra responsibilities around the house, time by myself, and endless words of encouragement. Writing this page makes me think I will never hear Zoe ask, "Are you working on the paper from when I was a baby?"

Outside my family, I would like to thank all the wonderful educators who have imparted their knowledge upon me. This group has helped me to not only learn content, but also learn how to apply knowledge to life, which is where it has its greatest value. In finishing this project, I must mention the fabulous staff at Chicago State University who have offered more support, dialogue, and information than I could have asked for when I began this program just over four years ago. I would like to specifically thank my committee Dr. Crystal Laura, Dr. Nancy Grim Hunter, and Dr. Margaret Carroll for their donations of time and wisdom to this project. Finally, I would like to thank my dissertation chairperson Dr. Byung-In Seo for her countless conversations and discussions. She has provided me with the tools to be successful and pushed me to look at things from new angles. During this process, she has become more than my chair, but a friend and mentor who inspires people to reach their true potential.

Biographical Sketch: Michael Thomas has spent his life in education; from the time he was small, he would work with his aunt cleaning her science classroom and grading papers. He then went on to Eastern Michigan University, where he earned a B.S. in Education, with certifications in Biology and Chemistry. He later earned a Master's degree from Governors State University in Educational Administration.

As a teacher, Mr. Thomas began his career student teaching, and later working as a substitute teacher at Woodhaven High School in Woodhaven, MI. Shortly thereafter, he moved to Chicago and began working at George Rodgers Clark HS/MS in Hammond, IN. Two years later, he took a job at Lincoln-Way Central High School in New Lenox, IL. There, he worked as a science teacher, dean, and coached multiple sports. He then returned to the classroom full time taking a job at Thornridge High School where he taught Physics and coached football. During this time, Mr. Thomas decided to begin his journey at Chicago State University. While working on his Doctorate, Mr. Thomas left Thornridge to become the Science Department Chairperson at Evergreen Park Community High School. In this role, he works with both students and with other educators as a teacher and leader.

Chapter 1: Introduction

Introduction

As a secondary level science teacher, I observe that there has long been a disconnection in terms of the content knowledge and the practical application of students in science. Traditional state standards, such as the Illinois Learning Standards for Science, have 66 standards, most of which focus on students' abilities to describe, recall, or analyze information (Illinois State Board of Education [ISBE], 2015). These standards were used for decades and focused on the ability to replicate information, rather than using the skills of the scientific process to discover information and create meaning for the students themselves. For science teachers, more time was spent telling students what they should know instead of providing opportunities for them to discover the information for themselves.

The Common Core State Standards (CCSS) forced teachers and educators to change their priorities and practices. This shift from large-scale factual knowledge to emphasis on skills and transformation of information has created a new educational dynamic. As a result, the Next Generation Science Standards (NGSS) were developed. NGSS looked to change the dynamics from just knowing scientific facts to being able to complete scientific processes, while still focusing on the same conceptual understandings in core science areas. Intertwined standards for Disciplinary Core Ideas (DCI), Crosscutting Concepts, and Scientific and Engineering Practices have created a set of standards where the practices and thinking of scientists are just as relevant as the factual information. For many teachers and school systems, the shift in science educational focus has created a change in curricula and methodology. Focus shifted from understanding facts at basic levels to evaluating and synthesizing concepts from key topics.

By taking on a leadership role in science, I have a different perspective now, in looking at science education. Not only are leaders responsible for the implementation within their own classrooms, but they are also responsible for the implementation in other classrooms. In order to affect change in all science classrooms, the importance of looking at structures and processes that support the implementation of the NGSS need to be stressed. Structural and procedural needs and support must be identified so efforts of change take place in a specific direction. Presentation of these structures and processes must also support all members so they can add their individual skills to collectively make changes in alignment with the needs of the NGSS. Veteran teachers are now being asked to reevaluate, and in some cases, completely overhaul their teaching methods. Research on systems of support to help with implementation of new methods are critical so that these educational transformations and increased educational accountability efforts of change can happen with minimal error.

Background of the Study

In today's technological world, all students should have the opportunity to a well-rounded, high quality science education, which will give them the opportunity to transition

to college or science-related careers (National Science Teacher Association [NSTA], 2013). Science education has primarily been focused on content knowledge and memorization of facts in isolation of skills application (ISBE, 2015). As a result, students can answer specific test items, but cannot apply their knowledge to other areas. Use of multiple choice standardized tests to evaluate school performance in science has also helped to push the identification of multiple terms and scientific facts in many science curricula (ISBE, 2015; Jorgenson & Vanosdall, 2002). Breadth of content coverage, ensuring that students would know the information that could be present on the state and national assessments, has left a generation knowing many facts. "Depth, not breadth" is a recent phrase in education that describes the ability to dig deeper and truly understand a topic, rather than just memorize terms and scratch the surface of the topic (Jackson, Dukerich, & Hestenes, 2008).

To address these problems, new national standards for science — the Next Generation Science Standards (NGSS) — have been developed to teach science content through application (Achieve, 2015a). Topics are interconnected so students can see a bigger picture of science. Isolation of content and skills has been shown to segment student learning, which makes it difficult for the students to then apply the content taught or transfer it to other applications (Jacobson & Wilensky, 2006). Learning in isolation enforces specific skills with specific content, but does not allow for students to develop a system to apply skills across multiple areas. As a result, students who lack transferable skills continue to misplace content and the skills to apply them (Ackerman & Perkins, 1989). Cross-cutting concepts, along with science and engineering practices have been included in the NGSS to ensure that skills learned at one level can be transferred to learning at more advanced levels.

These curriculum changes have typically been met with resistance, because many educators would have to change their current practices and learn a new way of thinking and teaching (Baron, 2015). Teaching integrated engineering processes, which is new to some science educators, would require multiple hours of professional development. This kind of professional development is important in building teacher capacity, but it can often be hard to obtain (Al Salami, Makela, & de Miranda, 2017). Without proper professional development, teachers without the current capacity to integrate science and engineering skills could struggle with implementation, resulting in confusion and enforcing previous problems with transferring science content to science practice.

Teacher resistance to curriculum changes can occur for many reasons: increased workload, loss of control or routine, feelings of uncertainty, loss of face, and/or fear of future competency (Mancabelli, 2011). These fears are the reality of many current science teachers who face these curriculum changes with the adoption of the NGSS.

To address these fears, structures and processes need to be put into place, which can allow teachers to use new teaching strategies in a supportive environment. Administration must also provide training and professional development, so teachers can familiarize themselves with the most recent and relevant strategies before, during, and after changes have been made.

Statement of the Problem

Education has seen many changes in recent years. From No Child Left Behind to Race to the Top to Common Core State Standards and the Next Generation Science Standards, American education is continuously creating new policies to try to merge current knowledge and instruction to the future needs of students. Reforms have left schools moving to new methodologies, even though these schools have limited time and/or resources to make the effective changes. In many cases, schools with the lowest scores are the schools changing most frequently, with the least amount of support (Bryant, 2015; U.S. Department of Education [USDE], 2011).

Policy change must include both a change in structures and support for those changes in order to ensure that the vision of the change becomes the practice in the classroom (Burke, 2014; Schubert, 1986). Changes must include structures to support teachers' understanding of how the changes should take place and how to help correct problems they encounter. Together, the structures and support for teachers give a better shared understanding and capacity to enact change that could allow policy to transfer into practice (Irvine & Price, 2014). …

Creating structures that allow teachers to be supported as they transition to the demands of current science education is one way in which new standards can truly be integrated into the curriculum and routine instruction of science. Structures can help provide teachers with resources and information to make sure they not only know what they need to do to meet the new standards, but also provide the techniques and processes that will help them achieve them.

…

Educational leaders come from a variety of disciplines, and many are attempting to make changes in areas outside their expertise to stay in alignment with new national standards. Problems can arise when those in power have limited resources or knowledge. In science education, curricular decisions are being made at an administrative level, often by someone with limited or no science background (NSTA, 2016).

Administrators with limited science education experience should look to research and literature on science methodology and pedagogy. Modeling Instruction (MI) is a proven secondary-level science education program (Jackson, 2015), which has been used by individual teachers who believe in the approach. However, there are also schools, not just individuals, using MI, and those schools have been successful (Hestenes, 2009). This pedagogy has the potential to improve science education at the district level.

Purpose of the Study

This study examined the structures and processes that have allowed a high school to successfully move from traditional classroom instruction to Modeling Instruction. NGSS places emphasis on students generating content knowledge by following science practices and creating meaning to observations and experimentation (Achieve, 2015a). MI is a program that teaches conceptual science knowledge through scaffolded activities and specific meaning-making observations (Jackson et al., 2008). Similarities between NGSS and MI exist in both content and methodology. However, both

may be different than the methods taught to teachers in their teacher preparation programs. Many teachers attempt to reach these goals by first teaching content and then supporting the information with a laboratory activity, confirming the information, rather than discovering it. As an investigative science curriculum, MI treats the activity as a tool to develop knowledge, promoting student learning, conceptual structures, epistemic frameworks, and social processes (Duschl, 2009).

Examining the ways in which a high school is able to successfully educate its faculty to meet the needs of the NGSS, as well as the needs of its students, can provide a model for other schools that want to make similar changes. Science departments across the country may need to eventually align to the NGSS, as many states are adopting them fully as their new state standards (Achieve, 2015c). School leaders could benefit from the knowledge of how a successful large-scale change in science education has happened. Changes of this magnitude can cause a reevaluation of the perspectives of students, teachers, administrators, and community stakeholders (Fullan, 2007). Teachers must look at the reasons for why they were using the previous methodology and determine how and why to accept the new changes. Students and administrators must also adapt to a new classroom dynamic, and change how the classroom and learning would appear (Guo, 2012).

Outside science instruction, many of the school structures that allow for the successful transition to MI may be used for schools to transform other content areas to align with the CCSS. Structural changes in one content area may also be able to impart change in another content area, as teachers support each other and drive the organization towards increasing student skills across curriculum (Cummings & Worley, 2015).

Significance of the Study

Education has evolved from an early background of teaching the young how to survive into using curriculum to obtain knowledge and develop one's senses (Ozmon, 2012). Currently, education is also used to promote specific skills relevant to the workforce and becoming a functioning member of society. Internationally, countries are putting resources into education in an attempt to create a better society and generate a stable and functioning economy. Science education is important. The global demand of Science, Technology, Engineering, and Mathematics (STEM) is great. In 2013, there were 5.7 billion job openings globally, with potential growth in future years (Bidwell, 2014). Proper training in science education could lead to innovative students moving the economic development of countries on a global scale. Companies would fill positions with local citizens, rather than outsourcing jobs.

Analysis of the structures of innovative science education can allow for educational organizations to better serve their students and better allocate the limited resources they often receive. In the United States, about 60% of the total educational expenditures go to instruction (Cornman, 2015), but the use of those funds must go to every content area and cover other daily materials, such as office supplies. Resources, such as time and money, are also spent on professional development to improve instruction. However, analysis of professional development shows that both teachers and administration often feel unsatisfied with the activity, and little change occurs in educational practice (Bill and Melinda Gates Foundation, 2014). Policy, professional development, and other top-down approaches do

not move teachers to more innovative instructional practices (Petrilli, 2014). Top-down, or first-order, changes often become hybrids of the old and new methods, where teachers attempt to make the new methods fit within the structures of what they were already doing (Cuban, 2013). Evaluation of a systematic approach that leads to teacher change and change in educational practice could identify where to allocate resources in order to effectively meet the needs of both the district staff and students. Schools, as systems, make relatively small changes, but those changes can result in large-scale re-learning by teachers, students, and other stakeholders (American Association of School Administrators [AASA], 2008). Identifying successful structures for change can create a way to replicate theory into practice, as new structures can facilitate and support the necessary changes in both curriculum and teaching methodology (Baker, 2013).

Development of quality, research-based science curriculum is important in pushing students to become thinkers who can solve problems and generate new ideas. Science education, which includes engineering design principles, teaches students to critically analyze multiple inputs to reach a conclusion and develop new solutions to problems (Litzinger, Lattuca, Hadgraft, & Newsetter, 2011). The ability to generate ideas and solutions is not only vital to the science community, but also to the development of business and economic value (Ledley, 2012). Large-scale idea generation is a consistent statistical predictor of success on meeting challenges and in being a successful company or industry (Spencer & Woods, 2010). The impact of science education that places emphasis on problem solving and generating ideas can have a much wider effect than the simple identification of content knowledge. Teaching problem-solving skills increases both learning and processing skills, while minimizing misconceptions (Akınoğlu & Tandoğan, 2007). Students with the ability to problem solve are better prepared to make connections between science content and applications, which allows them to actively assemble the building blocks of knowledge (Jones-Wilson, 2005).

Theoretical Framework

Schools function as learning organizations, with leadership organizing the members to achieve the desired outcomes (Hiatt-Michael, 2001). Desired outcomes for schools center on student learning, but defining student learning can differ greatly by the source and the methods used to achieve learning. Even though they may differ by the types of knowledge and skills taught, each school is an organization for this primary purpose. This purpose can also be reached in many ways. Thus, looking at the organizational theory behind successful schools can provide understanding on how to be successful.

Organizational theory helps to identify the structures, systems, and culture that define the school. Schools, as organizations, must account for all of these factors, as well as their impact on the stakeholders served. This theory looks at the roles of the individual stakeholders and systems, and their impact on the goals of the organization (Chance, 2009). Bureaucratic systems, such as education, often have multiple dimensions, so looking at the way in which bureaucracy can support goals is important (Hoy, 2013).

The structure of organizations can be defined as the way in which they divide their labor into individual tasks (Mintzberg, 1979). In education, structure can refer to the people or the programs; both must be organized optimally for long-term success.

Bureaucratic expectations, or policy, create a formal set of expectations for the organization that lead to the building of the organizational structure (Hoy, 2013). Policy frameworks can dictate the values and beliefs of the organization, which then affect the structural, constitutive, and technical dimensions (Cooper, Fusarelli, & Randall, 2004). Within these dimensions, expectations are laid out for various organizational groups and the exchanges between them. These expectations lay out the foundations for appropriate behaviors of individuals in their roles and can outline how members in one role interact with members in other roles (Hoy, 2013). Foundations for what will be done, who will do it, and how it will be done are also created in policy, outlining the structure for how the organization will operate (Cooper et al., 2004).

Members, or individuals, who are part of the organization in some capacity play a role, not only in the organization of structures, but also in the enforcement of the structures. Educational systems, due to their cooperative nature with their own members, the community, government, and other professional education organizations, are often loosely coupled with these other organizations in an attempt to balance the professional opinions of the members with the bureaucratic structures that are put in place (Hoy, 2013; Weick, 1976). Loose coupling states that coupled events, or events that occur in part of each other, are responsive to each other (Weick, 1976). Responsiveness is a way in which the events can affect each other and potential future reactions by the organization. Each event has its individual identity, and the coupling can vary over time. As a result, schools can be responsive to events and treat each situation as its own identity, giving it separateness (Weick, 1976). Separateness is essential to schools that have multiple interactions, from multiple members, and must be able to treat each interaction as its own. Structural looseness can allow for an organization to be responsive and adaptable by creating multiple interpretations of the policy, but these individual interpretations can also be a reason why the organization fails to meet its policy expectations (Hoy, 2013). Structures are often put into place to ensure organizational goals are met; deviation, regardless of the rationale for it, can result in unsuccessful operations. Therefore, schools must make sure that those interpreting policies are consistent with the structural framework.

School structures include the way in which operations and tasks are completed. Bureaucratic policy, at the federal, state, and local level, often help to control these structures by placing guidelines for how operations should take place. Each of these bodies contributes to the way in which schools operate and function. For example, a change in national education objectives can cause states to change policy, which then trickles down to changes in local policy. Changes at any of these levels can affect the day-to-day operations at the school level, so each policy change must be evaluated or investigated to identify the reasons why and how the changes take place. Policy change at any level attempts to improve the operations of the school, but it does not always improve in practice. As a result, articulation of the rationale and implementation of the policy may be necessary (Manna, Kelley, & Hess, 2012).

Science education is currently facing bureaucratic structural changes, from both the federal and state levels, through the recommendation of NGSS. This shift of focusing on science practices over science content knowledge is changing the structure of science education as a whole. Science education has been focused on the facts; the focus is now on

the application of those facts. The application is changing structures at many levels, from the design of the curriculum, to the physical space, to the roles and expectations of the individuals in the classroom. The shift in the focus of science has an impact on many of the structures involved in the day-to-day operations.

Routines are an important part of organizations, impacting both the systems and culture of an organization. Schools have many routines that can boost morale, increase student success, or hinder processes. Consistent routines can provide a level of support and comfort to individuals, as it allows for a predictable structure that guides the climate (Spagnola & Fiese, 2007). This consistency can be beneficial for both teachers and students. Consistency can provide a cognitive framework for students and improve collegiality among teachers, both providing a strong benefit to the school climate (Irby & Clough, 2015). Benefits of consistency to the school and its staff come from everyone knowing what is expected, which also allows teachers to feel safe in exchanging ideas with one another (Tarter & Sabo, 1995). Over time, routines can have a positive or negative impact on the way in which changes take place in the school (Sherer & Spillane, 2011). Problems can arise with routines when they no longer meet the needs of the organization, but are continued out of habit. The fundamental basis of routines is opposition to change, so when change is needed, there can be resistance. However, organizations need to have the ability to change in order to meet the demands of new goals or new members. When change is focused on implementing a routine, such as a standardized testing procedure, the change can be assimilated more easily into practice (Sherer & Spillane, 2011). Routines can be changed, since it is the method in which a task is completed and does not require individuals to question their beliefs, such as changes in the rationale of how tasks are completed.

Many structures can be implemented to bring about success, but organizations must also rely on a leader who can follow the vision of the organization and inspire others to reach the outcomes intended by the group. Educational systems have leaders at different positions, each taking on specific responsibilities. Leaders of educational systems have a unique complexity, as they are leading an organization that is always in some form of transition. Reforms are changing the landscape of their routines, but the system may not have the current capacity to meet those changes (Portin, Alejano, Knapp, & Marzolf, 2006). Facing these obstacles, leaders must find ways to move the organization from where it is to where they want it to be.

Leadership theory looks at the way people can move others in an organization beyond the individuals' own intentional goals (Krishnan, 2005). Structures and processes allow these individuals to push others towards the success of organizational goal. These structures and processes can align the individuals' capabilities with the organizational goals to provide a culture where all members are moving in the same direction (McGuire, Palus, Pasmore, & Rhodes, 2015). School leaders must be able to share leadership, lead learning communities, use data to make decisions, monitor curriculum and instruction, and have a positive impact on staff (Stronge, Richard, & Catano, 2008).

There are many kinds of leadership theory. For this study, **the focus will be on three of them: Transactional leadership, servant leadership, and transformational**

leadership (Northouse, 2016). These three leadership styles are used, because research has shown that successful leaders use one and/or more of these styles (Bugenhagen, 2006). Leadership theories take into account the structures, as well as the beliefs, skills, and abilities of the individual who is in the leadership position (Capper & Green, 2016). Skills, beliefs, and abilities of the leader all play a role in why members of an organization would choose to follow specific protocols.

Leadership theory can vary, and the needs of educational organizations can be successful with multiple approaches. However, the leadership style should match the vision of the organization and its members. Matching leadership styles to organizational objectives can follow protocols for outcomes in many industries. Education, on the other hand, is an organization that transcends multiple classifications, thus, placing a specific leadership framework becomes increasingly difficult (Chen, 2006). Schools must meet the needs of multiple stakeholders (e.g. teachers, students, and parents), so school leadership must take into account the needs of all groups (Odhiambo & Hii, 2012). Complexities in school leadership roles and responsibilities can cause perceptions to differ between stakeholder groups who may have different agendas for what they would like to see the organization and its leader accomplish. The successful leader gets all stakeholders on board to make successful change.

Transactional leadership, also known as managerial leadership, provides supervision and organization. These leaders use rewards and consequences as a way to motivate subordinates. This type of leadership can be effective in most organizations, but can also have limitations with increased productivity, morale, and innovation (Hoy, 2013). Based on the characteristics of contingent rewards and management-by-exception, rewards are offered for effort and performance, and leaders give followers something they want in exchange for something they want (Bass, 1990). In a school setting, these rewards may look like a preferential teaching schedule in exchange for rewriting curriculum documents. Management-by-exception is based on interventions when standards are not met, which can be done actively or passively. In either case, the leader is not acting until mistakes have occurred (Bass, 1990). Active management-by-exception is where leaders constantly look for areas where standards are not being met. Passive management-by-exception creates a dynamic where the leaders are not looking for problems, but only act when problems are brought to their attention (Hoy, 2013). Based on these characteristics, transactional leadership is ideal for maintaining a system that must be run in a specific way, such as the military, but may not be the best fit for organizations that value creativity and innovation (Spahr, 2016). Organizations that involve creativity must have leaders who can inspire the next idea; these organizations will not advance if they are only looking for ways to correct mistakes and maintain the status quo. Recent changes in education have moved towards creative development, but many leaders may still be working in the transactional style. Changes in the demands of school administrators to move from managers, who made sure the building was run efficiently, to leaders, who are in classrooms improving instruction, have created a gap where those who were successful leaders in the past may not have the capacity to perform their new job requirements (Hull, 2012).

Transformational leadership takes advantage of collaborative innovation and motivation of all members with a focus on the shared goals of the organization.

Development of an individual's capacity within the organization, typically through the four I's, differentiate transformational leadership from transactional (Bass, 1990). The four I's of transformational leadership are (a) idealized influence, (b) inspirational motivation, (c) intellectual stimulation, and (d) individualized consideration. Idealized influence involves building trust and respect, which are helpful to leaders who are attempting to make fundamental changes to the organization, since members will be more apt to take risks with someone they trust (Hoy, 2013). Follow through on commitments, willingness to consider viewpoints of others, and professional responsibility are all ways in which leaders can build idealized influence. Inspirational motivation is based on the ideology that the leader can create a shared belief that the problems of the organization can be solved (Hoy, 2013). Communication can be essential in developing motivation, since an appealing vision must also be accompanied by goals that are obtainable and allow followers to see the progress towards the goal. Intellectual stimulation provides the thought, which questions old assumptions and looks for creative ways to solve problems (Hoy, 2013). In schools, intellectual stimulation is often done through targeted professional development activities that are designed to bring new thoughts and perspectives to members. Individualized consideration is a way in which the leader can help each member of the organization grow by paying attention to their individual strengths, weaknesses, and goals (Hoy, 2013). An example of individualized consideration in a school may be allowing a teacher to analyze the effectiveness of curriculum changes, since the teacher may have shown an interest in statistical analysis and data. During this process, individuals might also increase their knowledge of the curriculum, which again builds the capacity of the group. These characteristics summarize the transformational leader's belief in maximizing group functioning by increasing the relationships and capacity of the individuals (Bass & Riggio, 2006).

Shift in focus from the leader to the follower can increase the motivation of organization members by making them feel like part of the decision-making process, which can increase the outcomes and productivity (Tesfaw, 2014). Followers with input on organizational decisions can align organizational goals with personal goals, which allows for personal motivation towards reaching organizational goals. Group members under this leadership have the ability to adapt organizational goals to meet individuals' needs by expressing opinions and having a voice in the process, which adds incentive to their productivity (Hoy, 2013). Members in transformational organizations have more input and are encouraged to take on increased responsibility and to try new things. As a result, increased individual capacity and the total capacity of the organization grow. Collaboration, which is also important in education, has been proven to increase with transformational leadership styles, as these leaders promote individuals to take on multiple roles and responsibilities (Cha, Kim, Lee, & Bachrach, 2015). Increased collaboration and other techniques of transformational leadership have shown positive correlation with job satisfaction, which can relate to teacher retention and positive outcomes on student learning (Knox & Anfara Jr., 2013; Tesfaw, 2014). Teachers who enjoy their work and their superiors are often happier, which promotes a better school climate. Organizations with leaders who allow for followers to take on increased roles and bring about changes to the

organization often have followers who are more satisfied with their roles within the organization.

Servant leadership takes the development of individuals in the organization a step further, focusing on their development and well-being (Greenleaf, 2002). Individual development is the cornerstone of this framework, with the belief that leaders who develop their followers into additional leaders will increase the overall capacity of the organization. Servant leaders value relationships and also view the satisfaction of their followers as important. School leadership, as well as many service leadership positions, could benefit from this leadership theory, since their effect on individuals can go beyond the organization itself (Hoy, 2013). Training individuals for successful futures is the purpose of a school, so employing this type of leadership could help build followers into leaders in whatever future they choose.

Ten characteristics of servant leadership have been crafted: listening, empathy, healing, awareness, persuasion, conceptualization, foresight, stewardship, commitment to growth of people, and community builders (Spears, 2010). Organizational leaders can still find success when focusing on only a few of these characteristics, depending on the needs of the group (Katopol, 2015). Groups, such as schools, may find success with leaders who primarily focus on the commitment to growth of people. Other characteristics may help, but attempting to take on too many may decrease the emphasis, leading to lesser returns.

Servant leadership promotes functions that are aligned with the function of schools. School leaders exhibit characteristics of listening and empathy, which are characterized by the need to understand (Huitt, 2009). Schools are built on the foundation of understanding, and school leaders employ the skills of listening and empathy to provide safety and belonging to its members. Healing can also occur when individuals with problems feel as if others have listened and empathized with them. These three characteristics of servant leadership are part of the social-emotional base of schools, where compassion for all is necessary.

Awareness is a conscious identification of a stimulus, which can or cannot then be acted upon, based on the judgement and learned human behaviors of the individual (Bargh & Morsella, 2008). Schools work as an organization that helps individuals become aware of many social, educational, and cultural objectives. Being able to formulate ideas, which is the process of taking multiple inputs and reaching a logical output, can then bring about foresight. Foresight is focusing on the ability to make rational predictions of what is to come in the future. As an organization, schools use their curriculum to produce students and personnel with foresight, so their students can predict future needs and prevent future problems. Once identified, leadership in schools can address the future needs of the students and begin to align the curriculum so students can properly respond to changes that occur in their life as they transition to adulthood.

Stewardship, commitment to growth of people, and community builders work together to become functional parts of the whole. These characteristics build individuals, instilling character and values, who can then go back and make the community stronger. As a center for building both individuals and the community, schools play a major role in the development of these goals. Schools are a place where individuals from the community come together and focus on a curriculum and set of norms, which are often directly related

to the goals of the community. Leadership in schools must take into account how they are preparing students to be productive members of their community.

School leaders must be able to balance the goals of the organization with the individuals who make up the organization. As a result, multiple theories may be used to examine if there is a successful change in paradigm within the organization. These theories are examples of how leadership can take on various approaches in an attempt to achieve the same goal. Through these lenses, school leadership organization and how its members reach common goals were examined.

Research Question: What leadership styles, processes, and structures have allowed successful use of Modeling Instruction (MI) in a science department at a secondary education building?

Rationale

Science has continued to evolve in U.S. society, yet those in science education have often maintained a status quo, where curriculum and pedagogy are lagging behind science practice. Current research on science education favors learning the material through application, which is now evident in the three dimensions of the NGSS (Achieve, 2015a). School leaders have the ability to shape their schools and choose what the students should know, as well as how students should learn the content. Most school leaders do not implement large changes in curriculum or instruction because they do not want to disrupt the teachers and the culture of the school (Akin, 1994). Large changes in classroom dynamics are expected by current policy reform when introducing new standards, and MI is one science pedagogy that is aligned with those changes. The use of MI has been growing over the past few years in science departments, but it is often found in isolation, rather than being the chosen model for the school (Jackson, 2016). Analysis of school leadership that has successfully made these types of changes, moving to the use of MI throughout the building, can outline successful strategies for other schools and content areas looking to make similar changes.

Definition of Terms

For the purpose of this study, the following words will be used with the following definitions:

Direct Instruction – Classroom teaching technique where the teacher is directly passing information and instruction to students. This kind of instruction can include lecture or demonstrations where the teacher is the sole presenter of content, and students take a passive role in listening and/or note taking from what the teacher tells them (Rosenshine, 2008).

Inquiry – Constructivist learning model, where students actively discover information based on experience (Community Informatics Initiative [CII], 2010).

Professional Learning Community (PLC) – Also known as Teacher Collaboration Teams (TCT), groups of educators who work together with the goal of ensuring that all students

learn, by building a collaborative culture and establishing a focus on results. These groups typically pick specific goals and then work together to achieve them (Van Clay, Soldwedel, & Many, 2011).

Problem Solving – The process where students work to determine the answer to a question or solution to a problem. It includes development of the skills and practices to identify and control variables (Mayer, 2013).

Student-Led Instruction – Any teaching technique where the students are the focus of knowledge generation and creating understanding (Schug, 2003).

Teacher-Led Instruction – Any teaching technique where the teacher is the focus of knowledge generation and creating understanding (Schug, 2003).

Traditional Instruction – A setting where the teacher creates the class climate. Direct instruction is often used, and students have one goal, which is to regurgitate the information the teacher has told them. Recitation of recall information is the mode of assessment, and one common approach is given to learn each topic (Dimitrios, Labros, Nikolaos, Maria, & Athansios, 2013).

Conclusion

Leadership has the ability to make changes in the functioning of the school in order to best suit the needs of their students. Over the years, test scores have shown a lack of ability in science education; however, little change has come as a result. Policy, in the form of the NGSS, is now changing the standards from what students should know to include more of what students should be able to do. The incorporation of skills is a major hallmark of science and the process in which scientists use to solve problems.

Despite these changes, many school leaders still look at teacher-led classroom instruction as an effective way of teaching science, or these leaders choose not to disrupt the common practices they see inside classrooms.

Modeling Instruction (MI) is a science pedagogy that places the students at the center of the classroom, allowing them to investigate and create meaning for themselves. Some school leaders have chosen to move to MI as a method to teach science. Evaluating their leadership processes could help other schools and school leaders in making a similar change.

Chapter 2: Literature Review

Introduction

Science education has a long history of not meeting the demands of the educational community or the industry standards. Even though new policy has attempted to drive many changes for numerous reasons, educational practice has virtually stayed constant. Conflicts also exist between science teaching and the way researchers have shown how students learn science, further promoting the problems. Curricula have been designed around this research in order to meet these needs, but the end result is often little change in practice. Change in teaching practice can be difficult. Support for those making changes in science education is necessary, as the current practices are not meeting the needs of U.S. students, yet continue to be commonplace in U.S. schools.

Leadership's ability to provide training and support as faculty members begin to make these shifts can determine the success of the change. Successful changes result in successful results, which can lead to increased stability and fewer changes in subsequent years.

This chapter reviews the literature on science education topics. First is an overview on the history of science education content, next is science pedagogy, then problems with science education, and finally an overview of Modeling Instruction (MI).

Understanding Science Education Content

Education has existed in the United States since colonial times and has been seen as a way to develop a strong society. Founding fathers, such as Thomas Jefferson, believed education was necessary to exercise one's rights of citizenship. As early as the Northwest Ordinance of 1787, the United States began setting resources aside for the purpose of education (NCES, 1993). In 1867, the Department of Education was officially established, with the purpose of reporting the condition and progress of education to Congress. Throughout the next century, educational needs fluctuated with birth rates, as large population spikes necessitated an increase in the demands of the school system. An increase in the number of high-school age students during the 1940s and 1950s placed an additional stress on the system, as the attendance rate increased to 90 %. Attendance in secondary and post-secondary schooling also increased, with the number of women and minority students continuing with their education. These changes brought our schools to the current point where over 80 % of students complete high school (NCES, 2015).

Curricula in secondary schools has long been a debated topic, where the goals did not always meet the needs of every student. Primary schooling has curriculum that meets basic needs of all learners, such as the ability to read; however, secondary school is often full of detailed subject matter that may not be necessary for the livelihood of many taking the course. Secondary education in the United States was rooted in intellectually challenging work that would prepare students for post-secondary education, but this curriculum was taught to all students, with little choice given to the student. This trend continued until the early part of the 20th century when intellectuals, such as Edward Thorndike, determined that high schools should give choices, which would prepare all students for their chosen life's work. A choice in education grew throughout the 1960s and 1970s, but then began to face scrutiny in the 1980s after the publishing of *A Nation at Risk*.

Standards then began to be ushered in and legislated not only what courses students would need to take, but also what content should be covered within those courses (Lee & Ready, 2009). Changes in standards continued to be refined over the decades since, but the increase in student achievement continued to plateau.

Science education and curriculum became a part of the American educational landscape during the Industrial Revolution of the late 1800s. During this time, science was used to push the industries that were becoming part of society, and colleges and universities began to require course work for admissions (Osbourne, 2016). High schools created science curricula by modifying the curriculum use of abbreviated college texts. In the early 1900s, organization of secondary science began, moving science instruction to as early as seventh grade. During this time, it became customary to begin with general science in ninth grade, Biology in 10th grade, Physics in 11th grade, and Chemistry during 12th grade (Osbourne, 2016). Around 1930, science began to shift into lower grades, with general science being covered in seventh and eighth grade, which caused Biology to move into freshman year. This move opened the school calendar for advanced science courses to be taken during the four years of high school. Science continued to be taught as a body of facts, and interest increased through the 1950s to 1970s; however, interest in physical sciences such as Chemistry and Physics declined (Osbourne, 2016). Post 1970s, a push was made to increase science education, but courses continued to focus on individual disciplines, and the lack of creativity kept a disconnection with most students. A lack of innovation and focus on content standards maintained the status quo in science for the next few decades. During that time states began to look at standards that should be covered in each course. Illinois has used the State Learning Goals for science adopted in 1985, which then became reformed into the Illinois Learning Standards in 1997. Both focused on the content of subject matter (ISBE, 2015). New reforms, such as NGSS, which became effective in 2014, have recently emphasized standards that involve science practices and thinking; however, teachers and educators are still looking to adapt the classroom dynamics to match these standards.

Understanding Science Education Pedagogy

Curriculum can be described as a multifaceted way in which schools teach their students. "One's school curriculum includes *all* school experience" (Foshay, 2000, p. 1). This definition includes the content that is being taught, the methods used to teach the content, and the messages received by the students. Since a school's curriculum encompasses the entire school experience, schools must be diligent about what it should and should not include. For years, these choices were primarily made by the textbooks schools chose to use. Recently, however, the Internet has allowed schools to find resources and develop curriculum tailored to the desires they have for their students. This kind of freedom comes with a price, as accountability and reliability of Internet sources can be scarce (Romine & Banerjee, 2012).

Planning of the school's curriculum often involves decisions made by the current faculty, school administration, and national/local policy. These factors can guide schools in making decisions, but are fluid bodies that can change over time. As a result, curriculum must also change or face the risk of no longer serving the needs of the organization.

Curriculum development takes valuable resources, such as time and money, from the district, resulting in curriculum documents that, once developed, stay in use for too long and undergo little evaluation (Divoky & Taylor, 1996).

The organization of curriculum in secondary schools is often done by subject, with each course being determined by state or local policy as required or optional. Standards created represent the content knowledge that must be covered in the course, which are often dictated by state or federal guidelines. These standards can also influence the sequence in which the material is taught; sequence can also be influenced by educator preference, where educators consciously or subconsciously alter the prescribed sequence based on preference or student need. The learning environment is also partially controlled by the educator, who may be given guidelines from the school and provided with physical equipment to use, but has the freedom to arrange the space in a wide array of options. The organization of the learning environment can affect interpersonal, institutional, and psychosocial dimensions (Schubert, 1986). Instruction is then allowed to take place within the aforementioned constraints, which can vary greatly based on the person, structure, and model chosen to use.

Science content and methods must be used synergistically for students to learn the complete information and skills. Content in science changes, due to the nature of the subject and the never ending quest for understanding. Methods should adapt in order to allow students to experience the subject moreso than just being told about it. Many schools at both the secondary and university level are encouraging teachers "to move from the sage on the stage to the guide on the side" (Schuhmann, 2010, p. 67). Students agree by identifying successful teachers' use of role modeling, classroom discussions, and other interactive methods (Thorne, 2013; Williams, Sullivan, & Kohn, 2012). Once again, the integration of these elements of curriculum can produce a dynamic where students know what they should know, but also how it can be used.

Science is both a content and a process. In order to learn science, one must be proficient in both parts. For years, state and national standards have focused on the former and forgotten about the latter. Content or conceptual knowledge, while necessary, cannot push students forward with their thinking if they cannot apply it to any practical applications (Jolly, 2009). Teaching science content in isolation of skills would be like teaching someone to drive without a car. The interconnectedness of these concepts and skills must be taught synergistically for students to have a chance at obtaining the "big picture." Isolation of content and skills makes learning science more difficult for students who have to connect segmented information (Jacobson & Wilensky, 2006).

Science is a subject based on experimentation and observation, helping individuals construct knowledge and understanding of the world around them. Even though this constructivist approach is not always used in the classroom, it is the expectation of all students who go into a science field. The ability to isolate and control variables is necessary for students to be able to make observations and determine the causality between them (Klahr, 2005). Furthermore, learning in this manner allows for high rates of skill transfer, producing results that can be applicable to the working skills of many industries.

Current science policy standards written in the NGSS framework highlight this practical application. With the use of Crosscutting Concepts and Science and Engineering Practices (SEP) embedded into the content, schools are not only making students aware of

science, but also how to apply it (Achieve, 2015c). Crosscutting Concepts are seven intellectual tools that students will use across the disciplines of science: (a) patterns, (b) cause and effect, (c) scale, proportion, and quantity, (d) systems and system models, (e) energy and matter, (f) structure and function, and (g) stability and change (Achieve, 2013b). Science and engineering practices are the eight practices essential for all students to learn, which include: (a) asking questions (for science) and defining problems (for engineering), (b) developing and using models, (c) planning and carrying out investigations, (d) analyzing and interpreting data, (e) using mathematics and computational thinking, (f) constructing explanations (for science) and designing solutions (for engineering), (g) engaging in argument from evidence, and (f) obtaining, evaluating, and communicating information (Achieve, 2013a).

Teaching is the link between the information and how it is presented. Methods of information presentation can affect the message that students learn, regardless of the content being presented. Teacher-centered approaches typically imply a surface level of understanding, while student-centered approaches tend to relate to a deep understanding (Beausaert, Segers, & Wiltink, 2013). Research has shown that a variety of student-centered approaches, such as role playing and peer instruction, can produce significant gains in student comprehension when compared to other methods (Gok, 2013; Guha, 2013). Other studies have shown that these results can become less significant for large groups. Student enjoyment and engagement can increase with these types of activities, without a corresponding increase in student knowledge (Ishiyama, 2010). When comparing the teaching styles used in math, English, and science classes at both high- and low-performing schools, it was found that command and task styles, both of which do not promote critical thinking, were the primary teaching methods (Ngware, Mutisya, & Oketch, 2012). Mixed results from research have created an environment where student achievement is desired, but where the methods of obtaining it can be debated. Even in situations where curriculum and instructional methods are clearly defined, teachers still favored their personal preferences (Ozturk, 2012).

Teacher alignment can have a positive impact on student achievement. Alignment with content maps, teaching strategies used to teach specific content, can show the effective methods by comparing inputs and outputs on achievement (Porter, Smithson, Blank, & Zeidner, 2007). A comparison of what was done to teach and how it effects learning can only be done if there is an agreed upon target and the alignment is of sufficient quality. Educators often disagree to what the target of student learning should be, or which methods to use to assess the target, making alignment and the ability to compare inputs and outputs difficult (Porter et al., 2007). Once targets are agreed upon and teacher alignment is provided in content maps, information gathered from assessments can then be used to change instruction and methods. Use of this information can be included in curriculum guidelines to show how instructional techniques affect student learning and then be supported by professional development to provide teachers with time and resources to develop concrete strategies that can better allow them to facilitate information (Chang, Chang, & Tseng, 2010). These techniques were found to be some of the most researched and relevant topics in education over the past 20 years.

Linking teaching style to student achievement allows teachers to focus on the primary function of their position, which is to educate and enlighten students. This multi-tier objective hinges on many factors, including teacher-student relationships, student engagement, time on topic, and many others (Ishiyama, 2010; Johnson, 2008; Maulana, Opdenakker, & Bosker, 2014; Schwartz, Sadler, Sonnert, & Tai, 2009).

Active learning is considered to be any activity where students are doing more than just listening to a lecture. Research shows that active learning produces higher levels of student engagement and more reflection on the student's own attitudes and beliefs (Ishiyama, 2010). Characteristics, such as reflection, are important to science education because science revolves around an analysis of what was observed and the potential reasons why it occured.

Student engagement is also a key factor in student success; engaged students take on an active role with the classroom content material. In school settings where the same content was covered but delivered with different methods, students produced greater results when actively using the information instead of passively receiving it. Both group discussion and student presentations were two specific skills in this study that were used exponentially more often in the active learning classrooms (Johnson, 2008). Science education should naturally lend itself to active learning through the use of hands-on experimentation, discussion, and analysis of the results.

Teacher-student relationships can have a positive impact on student motivation, which can lead to higher scores. In a study of 504 secondary school students, surveys were given at five different points throughout the year and then applied a multi-level growth curve model to assess the results, showing that relationships were key to student success (Maulana et al., 2014). Trust is a factor that cannot be written into the curriculum, but which needs to be developed, so students can feel supported when they struggle with new activities or instructions from their teacher. Relationships between students and teachers need time to develop. However, other factors, such as activities for active learning, can be accomplished with some fairly simple modifications in the class structure or the content delivery.

One example of modification is the use of questions, which has been proven to be an effective way for teachers to probe students for ideas and critical thinking. In a study of three teachers' science classes at an urban standards-based high school, the class with the most oral discourse, particularly student-student discourse, produced the most comprehensive answers based on evidence and reasoning (McNeill & Pimentel, 2010). Teachers often spend time on questioning to try and elicit responses from their students. Results show that open discussion with the teacher as moderator, to keep the discussion going, could be more productive. Critical thinking, though more time consuming as it calls for reflection and analysis, allows students to connect information and provide depth to their knowledge, which can impact long-term retention of the material being studied (Schwartz et al., 2009). These questions are often teacher generated for students. Changing this dynamic to one where students are both generating and answering the questions provides a level of discourse and understanding that allows them to not only clarify misconceptions, but also use evidence to support their claims (Eshach, Dor-Ziderman, & Yefroimsky, 2014; McNeill & Pimentel, 2010). Generating questions helps

students to be more critical when examining classroom content and provides a platform for self-analysis of misconceptions during the process of question development (Look, 2014). Students participating in open dialogue become accustomed to supporting their claims, as evidence is often necessary to support their opinion. When evidence is regularly used, misconceptions also weaken, as there is no support for them, and students can then relate them to being false (McNeill & Pimentel, 2010).

Educators should continue to look at simple changes in teaching methods so students can take a more direct role in learning and understanding. Many of these student-centered approaches also improve non-content skills, such as communication and interpersonal relationships, which are critical for students when they move beyond the classroom into the world (Guha, 2013).

Science is a subject centered around finding solutions to problems. The scientific method, which is the basis for experimentation, is a multi-part process that is integrated into almost every science curricula. Problem solving, in its basic definition, would include finding a solution to a need. Links between problem solving and creativity have been found to align with higher-order cognitive skills, increasing cognitive flexibility and the ability to use evidence-based reasoning, both fundamental characteristics of science education (DeHaan, 2009). Educators have looked at these theories for metacognitive awareness in order to develop programs for improving reasoning and problem-solving skills (Glaser, 1984). Despite this research, problem solving continues to be an area of weakness for many students, including those in problem-solving contents like science and engineering. Mismatches in student-learning styles and teaching styles can create an environment where the methods being used to instruct, as well as the skills the student has for acquiring information, are not working together; this can inhibit students' abilities in using these skills and transfering them to other areas (Felder & Silverman, 1988). Instruction that does not balance these two aspects may have one message delivered, but a different message understood: such is the case where the teacher states that something was taught, but assessment data shows that students did not learn the information.

Robert Marzano (2014) suggests using a multistep approach to problem solving so teachers can make sure students leave with the proper learning/message being taught. His approach consists of seven steps that teaches students to move through the identification of the problem, maintaining optimism in finding the solution, identifying possible solutions, evaluating resources, testing possible solutions, retesting and modifying, and ultimately choosing another goal to solve the problem (Marzano, 2014). Identification of the problem suggests that students not only look at the problem they are confronted with, but must also determine if the problem is worth the time and energy to solve. Maintaining optimism is where teachers can train students to replace negative self-talk, which is detrimental to the process, with positive statements. Identifying possible solutions includes isolating the individual block that is preventing the solution, and then thinking of ways in which one can overcome that obstacle. Evaluating resources involves the student taking all possible solutions and comparing them to the resources available to see if the solution is possible with the given restraints. Testing possible solutions should begin with the solution the student believes is most feasible. Retesting occurs only when the first attempt is

unsuccessful, and may involve changing the method based on newly found obstacles, or choosing a new method altogether. Choosing another goal is the last step, and should only be done when the student finds there is no possibility under the circumstances that the goal can be achieved. These steps are standard to the scientific method, but must be performed by the students in order for them to develop the skills. Oftentimes, teachers eliminate the sources of contention for students, but providing them additional information or having all students use the same solution inhibits the students' ability to persevere and problem solve (Carson, 2007).

Teaching problem solving relies on the teaching of skills. Once introduced, skills can be taught with carefully designed lesson plans, allowing students time to think and discover solutions for themselves (Malik & Iqbal, 2011). Traditional lesson plans and the traditional advice of "work harder" does not allow students to problem solve; many students do not inherently have techniques that allow them to make these decisions, especially under the pressures of many classroom environments (Ranade & Corrales, 2013). Case studies of engineering students at the University of Michigan found that most instructional goals focused on cognitive skills when methods that helped students embrace ambiguity, reflection and the avoidance of premature closure could greatly improve their skills. These feelings often arise in problem-solving tasks, such as engineering, and can be improved so students can think creatively and generate new solutions (Daly, Mosyjowski, & Seifert, 2014). Students who have been taught skills can then use them in a variety of ways allowing these students to adapt to new ideas and develop solutions. These methods should be taught and practiced, as opposed to disorganized thinking or specific instruction that cannot be easily applied to other areas (Barak, 2009).

Problems with Science Education

Science education has had many changes over the years. From the launch of Sputnik, which put science education in the forefront of the minds of many citizens, to the struggle to meet the scientific and technological demands of current society. For many years, the failure to formally test science in schools created an environment where science was not an essential part of education, but rather a course that was inserted into the curriculum when teachers had extra time in the school day (Jorgenson & Vanosdall, 2002).

Once added to state-based standardized testing, science examinations did not help shape the teaching of science. Most schools took the approach of having students learn the breadth of the content as opposed to using this content in practical terms (Jorgenson & Vanosdall, 2002). Multiple choice preparation did not match the detail and skill development of science education, and teaching for those purposes has had little impact on the student's ability to solve problems and create innovation. This lack in alignment between the assessments and research practices creates data that is not useful, thus, can have schools focusing on irrelevant content (Anderson, 2012).

While research has created many changes in policy, there has been little change in terms of practice. Educational practice in science has not evolved at the same rate as science and scientific thinking. The reasoning for this ranges from the regards of science in society, to the overwhelming amount of data on how science should be taught, to the difficulty of the content for many adults to understand. Science is a difficult subject for

many to understand and can often have research supporting multiple differing contextual theories, such as Newtonian and Hamiltonian mechanics. New science data and findings can also change information from that previously taught in school, such as the Big Bang Theory. Current science content can also disagree with personal beliefs, such as the theory of evolution, which can lead to students not wanting to accept information. Failure to identify or agree with current science content leads to many Americans believing in previous misconceptions, despite credible evidence supporting other opinions. Educators then have a hard time translating this research into classroom practice, as many students arrive with preconceptions that are at odds with what is being presented in the classroom (Landrum & Tankersley, 2004).

Research on science instruction also has many viewpoints, which leads to the debate of how science should be taught, with opposing viewpoints from inquiry to direct instruction (West & Skoog, 2006). The lack of science understanding by leaders in many schools creates a system where the administrators allow science teachers to continue with ineffective practices rather than looking at the research and trying to enact change in their schools. Science examination data can create negative perceptions towards both the testing and policy behind the testing. In many cases, the examinations rarely match the research on how science should be taught (Anderson, 2012).

International exams, such as PISA and TIMSS, provide data that shows disparities in the ability level of American students when compared to other countries. However, policy that should be used to change practice ultimately maintains the status quo (Fensham, 2009). This inability to affect the science practices used in U.S. classrooms, despite consistent assessment results, keeps students from being able to compete on the global platform. Combined with content that is always innovative and changing, the continuation of the status quo in science instruction creates a problematic environment where students are not getting the tools they need. Reform efforts in education, unlike in the business world, are often unsuccessful because it is not necessary for individuals and organizations with power to adapt to societal preferences (Hess, 2013).

The history of science education in the United States has faced challenges. The United States is not alone in its struggles as studies from other countries have also reported trends of negative responses towards science in schools. A Norwegian study pointed to science as a course that secondary school students took strategically with the belief that it would lead to future benefits, not because they were interested in the content matter. This quantitative study looked at 1,628 upper secondary school students and found that students chose courses based on interests, a fit to personal beliefs, and strategic utility reasons. A lack of interest and engagement has not been shown to produce results. Students who take courses with only the interest in the ends and not the means do not dive into the content with the depth needed for true understanding, as they are not curious in the subject itself and only trying to obtain jobs and/or degrees in demand (Boe, 2012). Interest and engagement can be impacted by teaching methods, so different approaches may be able to help in these situations.

As stated previously, student achievement in science is poor, according to some data sources, such as standardized test scores. ACT reports that 36% of students met the college readiness standards in Science, as compared to 61% in English 41% in Math, and 44% in

Reading (ACT, 2016). These standards might seem low; however, the same report shows ACT score data to be 20.8 for Science, which is greater than the 20.1 score for English (ACT, 2016). Conflicting data makes it hard for educators to truly know what needs to be fixed, let alone the ways to fix it. PISA data, which compares 15-year-old U.S. students with 15-year-old students from other countries/territories, shows that American students scored 36th out of 65 countries (OECD, 2016). This data reported a 1.4% increase over the previous testing results, which is a sign of improvement. TIMSS assessments of 12th grade students from 15 countries reported that U.S. seniors ranked sixth out of nine on this global assessment in math and science (NCES 2016b). This was an improvement from the previous TIMSS assessment, where the United States ranked last of all the countries. Differences among these data sources could lead to information as to where U.S. students are struggling with science content and skills, as TIMSS assesses science conceptual understanding based on a framework, and PISA assesses science literacy through real-world contexts (NCES, 2004).

Research on science education in the United States has similar focus to the need of improving teaching and student understanding. Multiple reports and reforms have been created within the past 40 years to attempt to address the needs. Beginning with the standardization of science education in 1983 with the publishing of *A Nation at Risk*, goals for teaching science and science outcomes have not been achieved (National Commission on Excellence in Education, 2015). More recently, a blue-ribbon committee warned that the failure of America to improve in math and science could cause a loss in international competitiveness, its national security, and the quality of life for its citizens (Business-Higher Education Reform, 2005).

Techniques used to teach science have led to a variety of instructional strategies, such as inquiry, direct instruction, cooperative grouping, and hands-on learning, with each showing promise in specific situations, but not being able to solve every problem (Clewell et al., 2004). Teacher qualifications also vary, as many science educators are lacking content knowledge, by having limited hours in the subject they teach, or lacking the pedagolocial framework to transfer their knowledge to students (Hestenes, 2010). These results show that more work needs to go into the shaping of both science pedagogy and the training of science teachers to properly implement the current pedagogy.

Understanding Modeling Instruction (MI)

Modeling Instruction (MI) is a student-led classroom instructional pedagogy that has been developed and evolving to teach science in a practical manner. Development of this program began in the late 1980s with David Hestenes' research on physics education. He looked at pedagogy and curriculum in university physics classes.

To assess his results, Hestenes and doctoral student Malcolm Wells created and implemented the Force Concept Inventory (FCI). The FCI is an assessment that evaluates the understanding of Newtonian physics concepts, when compared to common sense answers (Hestenes, Wells, & Swackhamer, 1992). The FCI can therefore be used to evaluate the effectiveness of a physics course by comparing a student's ability to use Newtonian concepts over common sense choices, which shows a change in thought. Results of the FCI have been used to determine the instructional pedagogy of MI. Since

that time, partnership with the National Science Foundation (NSF) has allowed workshops on MI to move from Arizona State University to many different states (AMTA, 2015b; Hestenes, 2010). MI has evolved from its early days of only working on physics instruction to now including biology, chemistry, physical science, and middle school science. Earth science curriculum is also in the process of being developed (AMTA, 2015a).

…

MI is a specific teaching methodology, which is different from the general way in which the term modeling is used by many in the educational field. In other fields, modeling represents a physical model or teachers doing what they want the students to do. Concrete ideas are expressed as models. In MI, models are a series of scaffolded activities and structured experiences that allow students to create conceptual meaning from data gathered by their own experiences (Hestenes, 1996). This common experience drives the curriculum and allows students to gather factual evidence based on observation before giving it a label. In traditional science classroom experiences, the opposite is true; laboratory exercises are merely used to confirm what the students had previously been told (Driver, Asoko, Leach, Scott, & Mortimer, 1994). Careful planning and sequencing of units provide students with opportunities to construct knowledge; "whiteboard sessions" allow students to present findings, which help with communication skills and increase the opportunities to find and fix misconceptions (Jackson et al., 2008; Megowan-Romanowicz, 2010). These tools provide teachers with the ability to make rapid changes in the way instruction takes place and increase student learning (Hestenes, 2014). Rapid changes can occur by changing the classroom dynamics from a teacher-led classroom to a student-led classroom, which places students in the front of the classroom with their thoughts and misconceptions in full view. The ability to identify what the students know and where they have misconceptions allows for increased learning, by playing on strengths and eliminating weaknesses.

The FCI is the primary tool used in MI to evaluate the effectiveness of students' understanding of Newtonian physics. Students are given 30 multiple choice questions that check their misconceptions when using logic over the laws of physics (Hestenes et al., 1992). This assessment has produced significant results supporting the increased conceptual understanding that takes place when students are taught with the techniques of MI. A Florida International University study, which looked at five years of data from calculus-based physics, found that MI students had an increase in their odds of success by 6.73 times. Odds of success were determined by students earning a passing grade in introductory physics. Increases were also found for under-represented students, revealing that MI can allow them equal success in courses where the gap typically widens between minority and majority students (Brewe, Kramer, & O'Brien, 2008). Modeling and reasoning along with investigative inquiry were shown to have large effect sizes in classes taught using MI, while communicating and relating only produced smaller effect sizes. In science classrooms, modeling and reasoning, which was defined as the ability to formulate conclusions based on evidence in this study, and investigative inquiry, which was defined as the process of developing and testing a hypothesis, are paramount to meeting the needs of the scientific community and producing students who can compete globally (Fulmer &

Liang, 2013). These results show that MI is an effective way to increase many dimensions of students' understanding and ability.

In order to understand and comprehend a phenomena, individuals must be able to change their conceptual framework, so they can then have a place for the conceptual change (Jonassen, Strobel, & Gottdenker, 2005). Constructivist thinking has been used to describe the ability of MI to make changes in not only the learning, but also the science experience for students. Opportunities for content mastery and the idea that mistakes are going to happen, which need to be corrected, are all incorporated in MI. It is also important for students to build self-efficacy, a necessary component in their development (Sawtelle, Brewe, & Kramer, 2010). The interconnectedness of content and pedagogy allows students to experience an activity and then think like a scientist to derive an answer (Megowan-Romanowicz, 2010). Scientific thinking and reflection, along with the students presenting their findings and answering questions, produce more expert-like knowledge structures, which give students the depth of knowledge. Studies of metacognitive skills show that MI students produce fewer errors, and are able to catch and fix their errors at a higher rate than students in traditional courses (Malone, 2008). The ability to identify and correct mistakes is a basic key engineering principal in many of the technological fields that are growing on the global scale; it involves problem-solving skills (Ramsey & Baethe, 2013).

Student-led instructional techniques, such as MI, show a high level of student satisfaction when compared to teacher-led or direct instruction methods. Multiple representations of content have been shown to support learning and increase cognitive function (Ainsworth, 2006). Viewpoints on topics were also broadened, which can lead to increased outcomes by every member of the group. This multidimensional instruction gives students an environment where they can let go of misconceptions and adapt to the results discovered by the group (Frame et al., 2015). Engagement, as measured by the students completing optional assignments, also increased since students took ownership of the material and spent more time with the material (Bernot & Metzler, 2014). This time on content outside the instructional time can increase academic achievement as well by giving the students more chances to apply content learned in class.

Conclusion

Science education has had many hurdles to overcome since being introduced to public education. Despite policy changes to increase the role of science in public education, student responses have often been limited, and the goals of creating students who can create innovative ideas have not been reached. Factual content has comprised the bulk of science curriculum and standards, and may be responsible for the limited change in student response.

New shifts, which place value on the process of science rather than just the identification of terms and content, may help to change the perception of the subject matter. Teaching pedagogy, such as those used in MI, which blends the information with process and experience, can give students a way to familiarize themselves with complex science content, while creating individualized meaning, since they will understand the science process while mastering the knowledge. Multiple representations have been shown to increase student comprehension, especially with complex material (Ainsworth, 2006). MI

uses this approach to increase understanding; increased understanding can also lead to increased satisfaction with the subject matter, which may allow education to finally reach the goal of increasing interest and ability in science.

Chapter 3: Methodology

Introduction

Science education has made many changes in the past few years, in both practice and in policy. Implementation of the Next Generation Science Standards (NGSS) has shifted the focus from knowing science content to utilizing science skills to solve problems (Achieve, 2015a). School systems used to performing under the Illinois Learning Standards for Science, which have been used for decades, will now have to change their methods and pedagogy to align with the new standards. Focus on deeper understanding and utilization of science is a contrast to the memorization of terms used in the past (Jackson et al., 2008). Systems of support must be provided to increase the capacity of staff in order to reach these goals, and the role of leadership in providing those structures will be critical to the success in reaching the goals of the policy.

Modeling Instruction (MI) is a pedagogy that aligns with many of the new science goals presented in NGSS, but it is often used by individual teachers or individual content areas within a department (Hestenes, 2009; Jackson, 2015). School-wide implementation takes on a new dimension, as this movement requires a paradigm shift by all stakeholders, not just the individual teachers who prefer this method. Large-scale pedagogical change needs to have a focused shift that identifies the transition of perspectives of these stakeholders, building the capacity of the group at the same time.

Research Design

Qualitative design is a research methodology conducted through intense or prolonged contact with participants in a natural setting. The goal of this type of research is to gain a holistic view of the context of the study, as well as an understanding of the situation from the perspectives of the participants. Data in a qualitative design is collected with words, which are often clustered or coded into groups for analysis and interpretation (Miles, Huberman, & Saldaña, 2014). Interpretations are made using a multi-step coding sequence, which will analyze the role of school leadership, through both the lens of the leader and those they lead.

A qualitative design was chosen for this study to gain an insight of how school leaders implemented MI throughout the science department in their high schools. This method is preferential to other designs, such as quantitative or mixed-methods, since the goal is to identify the characteristics of the leadership that allowed this transition to occur. Other methods would not allow for the rich perspectives of those involved in the change, which is necessary in evaluating the leadership styles, processes, and structures used to successfully implement MI. Quantitative data could be used to evaluate other aspects of the use of MI, but limited sample size for this study could make the quantitative data questionable. Mixed-methods could also be utilized, but again, due to limited potential candidates for this study, the focus on rich and quality information from those sources is the best approach to obtain ample data.

Case studies are qualitative designs that look at and describe a phenomenon when it occurs in some bounded context. Bounded context refers to the area in or around the case that can affect the outcome, and are defined by the boundaries in the sample (Miles et al.,

2014). Situations where a particular event has occurred within a certain set of parameters is an example of where a case study could be utilized. This study looked at a phenomena, such as the implementation of MI, in a particular setting and the individuals who have a role in it.

Research methods of case studies are of particular importance, since case studies involve a researcher obtaining data in order to give a holistic representation of phenomena. For case studies, Yin (2009) suggests five components of research design: (a) study questions, (b) study propositions, (c) units of analysis, (d) logic linking data to propositions, and (e) criteria for interpreting findings. Study questions involve defining the boundaries of a case study by the wording of the research question(s). Propositions are the components of the case, which deserve attention within the scope of the study. Units of analysis refer to the case(s) that will be investigated within the parameters of the initial research question. Logic linking data to propositions involves the methods used to analyze and group information based on the propositions in the study. Linking data to propositions can be done by a variety of analytic techniques, such as explanation building, pattern matching, or cross-case synthesis. Criteria for interpreting findings looks at the validity of the study and calls for the researcher to address rival theories/ideas (Yin, 2009).

In this particular case, **school leadership was studied in regards to its role in the implementation of MI in science education**. Small group behavior and school performance are both real-life events that would be applicable of a case study methodology. Case studies are used to answer research questions that focus on how and why an event took place, with a focus on contemporary events that took place at that time (Yin, 2009). This study looked at how school leadership played a role in the multiple events that took place for the implementation of MI. A case study tries to illuminate a set of decisions: Why they were taken, how were they implemented, and with what result? A case study is a descriptive way to explain what happened without the constraints of time (Schramm, 1971). This study also fits a case study methodology, as the school context is essential to understanding how leadership was able to make a successful shift to MI. Other forms of research (e.g. experiments, histories, and surveys) either separate the phenomena from the context or do not look at them in a deep and meaningful way (Yin, 2009).

A case study was the chosen method for this study, since this study looked at the characteristics of the school leadership that allowed implementation of MI throughout a science department sequence. The use of a case study is most applicable, as the contextual conditions of how the school went about this change is of importance to this study (Yin, 2009). Schools have a large structural system, so the importance of how the leader worked to evoke change within that context helped show the process of how change was made, and what elements had to be in place for the change to MI to occur. Phenomenology and narrative research could both look at the subjects going through this change, but are both based on an individual's own experience and not the specific characteristics of another individual who is allowing the change (Miles et al., 2014). Grounded theory is also inappropriate, since it has a goal of developing a general theory of the process, while this study looked at the details of the event (Miles et al., 2014).

This case study looked at the structures that allow a school to implement MI as the instructional method and pedagogy for science instruction. Case-study methodology is

appropriate in order to collect data on the individual perceptions of this change and to identify the various contents that have contributed to the success of the change. Interviews provided information on different leadership styles (e.g. transactional, transformational, and servant) allowing the researcher to learn how these affected the implementation of change.

Subjects

School Selection

The following criteria guided the selection of the schools used in this study:

- **The school implemented MI throughout the science department by offering MI courses in Biology, Chemistry, and Physics.**
- **The school is a grade 9-12 public high school.**

Contact with schools that met the criteria was made by sending an email via the American Modeling Teachers Association (AMTA) listserv (Appendix A). As a member of the AMTA, access is granted to post messages to other members on the listserv. This listserv includes thousands of individuals who have taken the training workshop and use MI. Trainers from a Midwestern MI training site were contacted to identify which local schools have had staff attend their workshops. Follow-up messages were given to the individuals or schools who have attended these workshops to learn if their implementation met the criteria. Schools that met this criteria were contacted to see if they would participate in this study**. Two schools met the criteria for the study, and both schools accepted the invitation to participate in this study.**

Leadership

Leadership includes those in a leadership position at the school, by title and job function. Principals, assistant principals, and other individuals responsible for instructional leadership and managerial operations would qualify as school leaders (National Association of Elementary School Principals [NAESP], 2016). Based on this criteria, **school leaders include district office personnel, principals, assistant principals, and department chairpersons.** Those involved in the shift from traditional science education to MI were of particular interest, as they helped determine the school needs and to develop the framework for implementation. Individuals in these roles are also required to build capacity within staff to meet new goals.

Faculty

Teachers were included in this study, since they are the ones responsible for carrying out the day-to-day operations of the new pedagogy. Structures put in place for the implementation of MI and evaluation of the program directly impact the role of the teacher and his or her effectiveness. The effect of leadership on the implementation and day-to-day management of instructional methods were identified by qualitative responses from the teachers on the overall effectiveness of the leadership in implementing MI. Information from these sources can be used to validate the overall view of the role of leadership on the school, and can provide information on how the faculty views leadership compared to how the leadership view themselves.

Participants were organized using a chart, which allowed demographic information to be recorded about the participants. This information allowed factors, such as education, years of experience, and subject matter, to also be analyzed when looking for trends in the data. Both school leaders and faculty were placed on the same chart, since background information of both groups helped to identify trends; multiple charts were used because more than one school participated.

Setting

Qualitative data was collected from interviews and observations. Interviews and observations were conducted and collected at a location of the subject's choice.

Data was collected from face-to-face interviews, written responses, observations, and other methods that allowed for assessment of the climate of the school and the structures put in place to implement and run the MI science courses. Methods of collecting data were dependent on the availability and preference of the school and school staff. This data collection process included meeting with the subjects at their school, email correspondence, and/or telephone conversations, which were transcribed. Perspective of the leadership roles was collected from the perceptions the faculty and of the leaders themselves. School leaders also gave input on how they worked with each other to implement the program.

Research Instruments

The research questions for this study were guided by the roles of school leaders who were able to successfully implement a science sequence using MI. Investigation included why schools chose to use the MI pedagogy, as well as who decided to look for a change in the way in which science was being taught. NGSS were also examined to see if adoption of new standards played a role in the pedagogical shift. Focus on the implementation process was of particular importance to the interview questions, as there are a variety of factors that can affect this stage. Also, organizational structures must be in place to ensure stakeholders do not view this shift as a failure before it has begun. Perceptions, which are defined as the way one thinks about or understands something, and perspectives, which are the mental views, were both evaluated to gain a better understanding of the process that took place and how it was viewed by those who were a part of the change (Merriam-Webster, 2016).

Interviews were completed with school leadership, as previously defined, using the questions found in Appendix C. Based on the definition of school leadership, the subjects of these interviews would include the principal, curriculum director, and science department chairperson. Questions for these interviews were developed by modifying questions from Coleman (2013) and Gershenoff (2002). Coleman (2013) was used as a guide to evaluate leadership, due to his instruments that examined the characteristics of school leadership. Gershenoff (2002) was also used to determine what questions would be used for leadership's role in curriculum change, since her study involved the roles of leadership during a planned change in curriculum. Both sources helped to develop interview questions and data collection tools, but modifications were made, as neither study focused on the role of leadership in science curriculum.

Interview data from school faculty was used to analyze the roles of the school leadership with the perspectives of those who are following them. Questions used for school faculty interviews were similar to those of the leadership interviews (Appendix D). These questions were developed using the same procedures as those for the leadership interviews, with many overlapping questions, which helped compare the answers given from each source.

Observations were completed at the school sites using a modified version of the observation checklist used in the Coleman (2013) dissertation**. A leadership checklist (Appendix E) was used to document data that supports various leadership styles, such as transformational, transactional, and servant. These three leadership styles were the primary styles examined.** Data taken allowed the leadership characteristics observed to be compared to those stated by both faculty and leadership themselves**. Another observation checklist (Appendix F) provided information about the school climate.** This checklist gathered data on (a) vision, (b) expectations, (c) leadership, (d) collaboration, (e) alignment to standards, (f) monitoring teaching and learning, (g) professional development, (h) learning environment, and (i) family/community involvement. School climate information was used to analyze the context in which this change was made and provided information as to the conditions allowing this change to take place.

Procedures

Before any data was collected, this study was approved by the Chicago State University Institutional Review Board. Contact was made at schools in the Midwestern United States that are implementing MI across science subjects through the science department chairperson at each building. An initial contact message was used to inquire and ask permission from participants. These individuals were initially contacted through email; if no response was received, then they were contacted by a telephone call. As a liaison between the teachers and the administration, the department chairperson became a contact point who could reach out to other faculty in the building to gain participants for research. Once contacted, the department chairperson determined which individuals should be interviewed and who should be observed, based on the department chairperson's knowledge of MI and the building leadership. Consent forms were then given to the members of the school leadership and faculty who were chosen for the study. Upon completion and collection of the consent forms, times were scheduled to meet and observe the participants. Interviews were then conducted face-to-face based on the needs of the participants. Participants selected the dates, times, and locations of the interviews in order to increase their level of comfort**. School leadership answered questions about themselves (Appendix C), while faculty answered similar questions based on their perceptions of their school leadership (Appendix D).** Participants determined how to answer the questions based on their level of comfort. Observations also took place at the school, and the observation checklist was used (Appendix E & F) to gain a first-hand experience of the leadership and school environment. Interviews were transcribed, and both interviews and observation data were coded to look for patterns in the data. Transcribed interviews were then compared to audio recorded interviews to ensure accuracy. Transcripts were then sent by email to the participants so they could evaluate the authenticity of what was recorded. Each participant was given time to look over the

transcripts and reply if any information recorded did not match their beliefs or what they were trying to convey. Once each participant agreed to the information transcribed, common themes and trends were identified and used to analyze the role of school leadership.

Data Analysis

Qualitative data was analyzed using a process that summarizes and codes the data by similar responses. These coded responses were then used to create a reality of the process in which MI took place at these two schools. Emphasis on the role of school leadership was viewed through the lenses of the leadership, their peers, and the teachers who were also part of the organization during this transition.

Coding of the responses began with a first cycle where interview answers were holistically coded by basic themes indentifying the roles and rationales for the school leadership's decisions in moving to MI. Faculty questions were marked by the same themes in regards to their perspectives of the school leadership's decisions. Analysis of this first coding cycle helped to determine if the school leaders and their faculty viewed the implementation of MI in the same regards. Use of holistic coding in this first cycle also condensed data, organizing it into patterns, which were again analyzed together as a collective group (Miles et al., 2014). Subcoding was also utilized in areas where code groups became large and needed to be divided further. This use of subcoding provided information of particular qualities specific to the process, which were then analyzed to view their effects (Miles et al., 2014).

A second coding cycle was then used to place codes into categories or themes of similar code, which was then analyzed for agreement or disagreement between the subjects of the study. During this second coding cycle, common categories were used for each school, so analysis of each school was done under similar constraints (Miles et al., 2014). Clusters of common themes were then analyzed using a matrix display to condense all the information in a chart for analytic purposes. This matrix combined the holistic codes from the first cycle with the themes found in the second cycle to produce an analysis of the reality of the leadership's role in the use of MI at the school (Miles et al., 2014).

Limitations

As a case study, this research is limited to the context in which the phenomena has occurred. Therefore, the results may not be representative of all school settings. Parameters set forth for inclusion limit the candidate pool and suggest certain requirements. The selected schools may have other contextual factors causing them to differ from other school settings. The use of interviews as a method of data collection could also limit the accuracy of the data, as some of the participants would be required to recall information and events from the past, which may have an effect of the perceived context at the time.

Delimitations

Further limitations were placed on this study by the researcher based on accessibility: (a) school-wide usage of MI for Biology, Chemistry, and Physics; (b) training of teachers in MI by certified AMTA workshop; (c) Midwestern United States secondary

school. These characteristics limit the schools that could participate and may not be representative of a larger population. This study has the focus on leadership. Other factors could have led to the implementation of MI at these schools, which may not be fully addressed.

Conclusion

The qualitative method of case study methodology was used for this study, as the case study focuses on the contemporary events that took place in order to allow the case to occur (Yin, 2009). Real-life contexts to how leadership was able to implement MI on a large scale within the science department is important to understand so others can identify and understand what parameters and leadership techniques are necessary to successfully make this type of change. Data obtained from both the school leadership and school faculty members allowed a holistic viewpoint for how the change was perceived by all sides, allowing the self-analysis of the leadership to be compared to the analysis of those following and providing the day-to-day operations.

Chapter 4: Results

Introduction

This research study examined the implementation of Modeling Instruction (MI), specifically the role of school leadership. It looked to examine schools that were implementing MI in Biology, Chemistry, and Physics. The goal of this study is to examine the role of leadership, along with the organizational structures and processes, which allowed for the implementation of this pedagogy. Data was collected from teachers, administrators, and department chairpersons at two schools that met the criteria for this study. Interviews of subjects were conducted, and transcripts were then sent to participants for member checking before coding and analysis. This chapter organizes the responses based upon those categories, and presents information gathered during interviews, observations, and other interactions.

School Demographics

Orange High School

Orange High School, located in a suburban community about 30 miles from the nearest major city has just over 2,000 students. The community is rich with academics, having several universities and colleges within the district boundaries. Income in the community is also higher than the average, with only 20% of students eligible for free or reduced lunch. Racial demographics are limited, with white student populations much higher than the average for the state; however, both Asian and Latino populations have continued to grow over the past few years. Academics are strong at the school, with 70% of the students meeting college readiness standards, compared with less than 50% for the state average (ISBE, 2017). Over 80% of the students at Orange High School also enroll in post-secondary education following high school. This school boasts a 0 % dropout rate. Awards, such as ranking as a top 50 school in the state, a *U.S. News and World Report* Silver Medal winner, and being an Advanced Placement (AP) Achievement District, also add to the academic merits of the school (ISBE, 2017).

Over 90% of the 178 staff are white teachers, with Asian and Latino being the only other categories to be just over 1 % (ISBE, 2017). Teachers at the school have high levels of education with over 90% of the faculty having a Master's Degree or higher (ISBE, 2017). Retention rates for faculty are also high at over 92%, when compared to 85% for the state (ISBE, 2017). Attendance rates are also higher than state averages, showing that teachers seem to like their jobs and attend on a daily basis.

Silver High School

Silver High School is just over 3,300 students and located in a suburban community about 9 miles from the nearest major city. The community has access via public transportation to a major city, which attracts those who work or attend school there. Income in the community is higher than average, with only 20% of students eligible for free or reduced lunch (ISBE, 2017). Median ($70,000) and average ($97,000) household incomes are also much higher than state and national averages (ISBE, 2017). Racial demographics are diverse, with white students comprising just over half the population, black students accounting for a quarter, and the remainder being a mix of Latino, Asian,

and multi-racial. Academics are strong at the school, with 70% of the students meeting college readiness standards, compared with less than 50% for the state average (ISBE, 2017). This school does have a particularly high achievement gap between black and white students with a difference in test scores of over 40%, which is well over the state average. Over 85% of the students at Silver High School enroll in college following high school; however the college remediation rate is below the state average (ISBE, 2017).

Faculty at Silver High School seem to be more diverse. Of the 231 teachers, just over 75% are white, with almost 10% each African-American and Latino. Teachers at the school have high levels of education, with over 85% of the faculty having a Master's Degree or higher (ISBE, 2017). Retention rates for faculty are also high at over 95%, which shows that teachers continue to work in the district (ISBE, 2017). Teacher attendance, defined as teachers missing 10 days or less, is lower than the state average (ISBE, 2017).

School Personnel

Table 1 lists school personnel who are mentioned in this study, along with the role they hold/held at the school. Teachers in regular font were interviewed, and teachers in bold font were not interviewed, but were mentioned in interviews. Their names and roles are included to help identify the role they played.

Table 1
List of Participants at Both Schools

Role	Orange High School	Silver High School
Department Chairperson	Mr. Maple	Mr. Pine
Assistant Principal	Ms. Apricot	Mr. Fir
Teacher Biology	Ms. Apple	Ms. Pear
Teacher Biology	Mr. Birch	Ms. Cherry
Teacher Chemistry	Ms. Plum	Ms. Mango
Teacher Chemistry		Mr. Willow
Teacher Physics	Mr. Aspen	Mr. Elm
Teacher Physics	Mr. Oak	Mr. Hickory
Former Teacher Physics	**Mr. Spruce**	
Teacher AP Chemistry		**Mr. Evergreen**

Administration

Orange High School

An administrative interview at Orange High School was with the Assistant Principal of Support and Enrichment, Ms. Apricot. Ms. Apricot has strong ties to Orange High School, as she has spent her entire 16-year career there, attended school there, and has

family members who still attend school there. In her role at the school, she supports teachers by bringing new and dynamic ideas to the classroom in an attempt to improve student learning.

Orange High School has a "strong community and family connection," according to Ms. Apricot. Community members often help at the school and the school makes efforts to "connect to those families who are not going to just naturally engage." These events range both in terms of the community members who they are looking to target and the influence those members have on the functionality of the school. Ms. Apricot explained the community meetings at the school:

Twice a month the principal holds a morning cup of coffee session where community members can come in and find out what is going on in the school. Community members can also ask questions of the administration at this time, but he tries to discuss both the academic and social-emotional things that are taking place in the building. More formal events like curriculum night and open house also allow for opportunities to interact with the community.

These events seem to allow two-way discussions about what the school is trying to get across to their students. However, it is also an avenue where community members can get clarification or question some of the ideas in which they might not fully agree.

Community support, in terms of programming, also takes place at Orange High School, helped by the many educational and business organizations within the district boundaries. Ms. Apricot explained, "We are starting an incubator and mobile maker class next year, which is kind of like *Shark Tank* for kids, so that's exciting. We have actual businesses and organization out in the community that will be involved." Experiences like this one allow the school and community to not only see what others are doing, but also build relationships that can help each group prosper.

Ms. Apricot describes her leadership style as being centered on relationships - "it's all about relationships for me. I think that's the key." She feels that having positive relationships with her teachers, and having them know that she will be there to support them, rather than point the blame at them, creates an environment where people "are willing to try new things and take risks." Collaboration and coaching are other issues that she stresses in her leadership, because they allow her to see why teachers do what they do and what she can do to make them better. "It feels like coaching for a big game day, versus evaluation." Ms. Apricot takes an active role in the group and uses her voice as an influence instead of a mandate.

Orange High School is very student centered, during observations students were free to wear headphones, send a text message, or chat near some lockers during passing periods. Ms. Apricot said that this environment was created by the teachers and staff with support of the building leadership. Administration has "pushed this idea of 100% for 100%," with school staff giving their all for students, and expecting students to reciprocate to meet the demands of the staff… Our building is focused on students, so when you start from that framework, then anything becomes possible."

This student-centered perspective includes both the academic and social-emotional components of the school. Teachers hold students to high expectations, but do whatever they can to help students meet them. For example, teachers may arrive early, stay late, or

use their lunch period to help students. Ms. Apricot and the school leadership also created a 25-minute period embedded within the day to give students additional access to their teachers and staff. Every person understands the expectations of the school. "Even traveling to games with our students, it's common for our principal to talk to the students in the stands and tell them, 'Here's what I expect from you as Tigers,' and even call them out when they're not making the right decisions." Support for both academic and behavioral needs seem to be common place. When two boys were walking down the hallway talking and getting a little rowdy, a teacher standing outside his door, asked them to stop. Not only did the boys stop, but they also apologized to the teacher.

Professional development is provided schoolwide and offered on an individual basis. Schoolwide professional development is often based on school initiatives or updating staff on new policies or practices. Individual professional development seems to be catered towards individuals, or even groups, who share a common interest. Group training, such as Socratic seminar training done by the English department, allows for individuals to learn the same techniques, where they can speak a common language and learn from each other during the process, which helps to build relationships among members within the department. Other trainings mentioned by Ms. Apricot involved "sending all the AP teachers to get all their AP related PD" and "sending 12 teachers to get trained as instructional coaches" can help bring collaboration between members of different departments who share common interests. Opportunities for growth seem to be available for faculty members who want to try something new or prepare themselves to take on new roles.

Professional development also takes place for science teachers at Orange High School, and other high school science teachers, as the school hosts MI workshops each year. These workshops take place for two weeks each summer. Even though the school administration does not participate, they do support these workshops financially, offering space/classrooms, and providing extra staffing when needed.

Ms. Apricot was not completely sure how MI at Orange High School began, but she believes it was with a teacher who asked to go to training and was supported along the way. Grassroots change has not only been supported, but also encouraged by the administration. Ms. Apricot stated, "I love it, because it only takes one person to get fired up and excited about it, and then look at the change that you can bring." Enthusiasm and support changed the way science is taught at Orange High School, where all new teachers must go through training in MI, even with the school hosting workshops for it each year. Workshops provide an "opportunity to collaborate and build relationships not only with our staff, but with others that we wouldn't ordinarily see." As Ms. Apricot put it, "This is the piece that I love about relationships and trust and risk-taking and supporting each other."

Silver High School

Interviews for Silver High School were conducted with Mr. Fir, who is the Assistant Principal for Instruction and in his 11th year at the school. He has worked at multiple districts in his career, having roles such as teacher, dean of discipline, and co-principal before beginning his current role.

Silver High School is in a very diverse community, and with that comes a wide variety of involvement from community members and organizations, each having different

needs and things they value. Overall, the community really supports the school, but Mr. Fir acknowledged that he has a hard time quantifying it. "It shows up in families having conversations with their students in the evening about their work, and these are things that the teacher or school may never know about, but it actually shows up in the students having their work done the next day and done at a high level." He feels that this support for the school happens, even though the school has no way to quantify it.

Differences or gaps do exist in the parents that do come to school events and programs. More affluent parents often help the school when the school has needs that may match their profession and/or training, which allows students opportunities they might not get in other buildings. These same parents also tend to openly voice their opinion when they have issues with what the school is doing. Many of the lower income families are not present as often in the building, but Mr. Fir says that situation is starting to change. Lower income students in the district typically move into the district to go to a better or safer school. "They sometimes come in with the base assumption that this is a good school and thus everything we do here will be best for their son or daughter." The school has recently tried to get more involvement from these groups, which historically had only come in to advocate for their children on limited situations, such as discipline, and try to create more equity amongst groups. Mr. Fir gave examples of equity issues.

Some of the things that have kept groups behind have been pretty subtle, but have an outsized impact. For example signing up for summer school, some families know that enrollment begins at noon on Wednesday and classes will fill up quickly, I think some classes fill up within five minutes, so at 12:05 they are closed. This means that families without access at 12:00 don't get in. On its face we may say that we are not doing anything to privilege one family over another, but in reality, even though it wasn't the intent, the impact favored one family over another.

Measures like the summer school situation are being corrected with collaboration from school and community members. Working to increase access to all programs for everyone that attends the school.

Mr. Fir describes himself as "a teacher leader" when assessing his own leadership style. He defined being a teacher leader as, "I think of myself as a teacher, even though I am not currently teaching any classes of students." He identifies himself with the daily routines that his teaching staff endure. "I want the people that I'm making decisions for to understand why the decision is being made," stated Mr. Fir. His past role as a teacher allows him to foresee where frustration will come from within the staff, so he is trying to prevent future conflict. In his role as an administrator, he knows that "it's not because I said so, it's not because you can do whatever you want, but decisions have to be made." Being forward about the rationale behind the decisions can help others see the logic behind the decision, even if they do not agree with the actual outcome. "If that requires some explanation, or a lot of explanation, and a lot of collaboration and listening, then that is the way it should happen," which speaks to the way Mr. Fir values the staff and their role in the school.

Mr. Fir attributes much of the school's success to the community where the students live and the resources it has to offer. School staff, and the ability to attract quality teachers, is another factor Mr. Fir mentions in terms of what makes the school successful. "We tend

to hire teachers who have taught somewhere else for a few years, so they have proven the mettle. Then, when you pool a number of those dynamic teachers together and give them some time and space to work and push each other, this is what happens."

The school environment at Silver High School is quite segregated with multiple class offerings, and each of them having multiple levels, from transitional to AP. The size of Silver High School, along with the availability of resources, make it a school where "many things are happening, but people don't always see because they are happening in different parts of the building." There is cross-over in some ways, but in others, there are students who never cross paths in their high school career. Some of these segregation problems have been ongoing for decades.

Instruction at Silver High School is tailored to the learner, with the goal being to place students in classrooms that will meet them at their current ability and push them as far as they can go. This leveling of courses by placing them with students of similar ability can be positive for students, but can also create some divisions in a school with diversity. Oftentimes, minority students are overrepresented in lower-level classes and underrepresented in upper-level classes.

Time for collaboration and professional development is difficult at Silver High School. "Our teachers love working with our students, and they like working with each other," says Mr. Fir. "They don't like to be forced to make a decision on whether they are going to work with their students or colleagues." Collaboration does take time, so when time is granted by the school, it does remove some instructional time from the school day. Mr. Fir notices how much time teachers already take out of their personal day saying, "teachers do a tremendous amount of work on their off time; this includes planning time at home, on weekends, and even during their summer." The school does give collaboration time — Teacher Collaboration Time (TCT) — similar to Professional Learning Communities (PLC), — where department members can meet to collaborate on various issues. "Classes are taught by three, four, five, and sometimes 10 teachers, so that provides a tremendous opportunity for collaboration."

Professional development is also handled in a similar way where the school tries to offer as much to the teachers as they can, but without removing some of the contact time with students. "We just made a proposal to transform a big part of our professional development to a coaching model," which would allow teachers to receive professional development without leaving their classroom. Teachers would become trained as coaches and then "given release periods to ride along with other teachers." Coaches would work with teachers both inside and outside the classroom to work on instruction and planning. As a result, teachers would have a contact person inside the building, which is not always possible when outside professional development is imposed onto the staff.

Mr. Fir was not sure on how MI began at Silver High School, but he responded, "It was before my time, and I'm not sure." He did say that teachers in the science department are offered training as part of their professional development, and the school pays for them to attend the workshops. Also, teachers are paid a per diem for the two weeks they spend at the workshop over the summer.

Department Chairperson

Orange High School

The department chairperson at Orange High School is Mr. Maple, who is in his fifth year as department chairperson and 19th year of teaching, 15 of which have been at Orange High School. Mr. Maple has an interesting role as the department chairperson; he is the leader of the science department, takes on most of the administrative duties for the science department, and teaches two classes during the day. This role is unique, as he is contracted as a teacher, but often put in places where he is making administrative decisions that affect other teachers.

When asked about the community, Mr. Maple responded, "I think community involvement is something we are struggling with." His response to the question on community involvement was followed by information with how much members of the community do for the school and how much money they raise for programs and activities, but this group did not represent all students. "I think the low income population is growing, and we need to figure out how to manage that." Parents also come from highly educated fields and work at major science laboratories, so changing science instruction also created some tension. However, after individuals came into the class and saw the routine instruction, most of them were convinced that the school was doing what was best for their children.

"Administrators talk a lot about leadership in meetings," says Mr. Maple. "Our bosses say we are leaders, but I think the department chair is more of a manager." Mr. Maple sees himself as one of the teachers in the science department who also takes on additional responsibilities, such as a budget, scheduling, curriculum, and evaluating. "I don't really think we are administrators," he says, "but I think the people in our department may feel that way sometimes." He describes his transition from teaching to the role of department chair as "being reluctantly drafted" with no aspirations of taking on this position. Collaboration and efficiency are characteristics that Mr. Maple stresses as keys to success and a functioning department. "I want the department to be the same way as I want the classrooms to be. Where I want kids to look forward to coming to class, I want members of this department to look forward to coming to this building every day." This openness was also seen during observations where Mr. Maple could not walk down the hall without being stopped by teachers asking questions or them asking him about making plans outside school hours. Openness was also seen as teachers kept coming into the room during the interview. Mr. Maple would stop to help the teachers get what they needed and then return to complete answering the questions.

When addressing the school, Mr. Maple's comment was, "The school environment is overwhelmingly positive." Comments were made about how happy the faculty at Orange High School were, and how that trickled down to the students and everyone in the building. He did mention that, like most schools, they did have problems from time to time, but "there is something special and kind and nice about the kids here." On the day Mr. Maple was interviewed at the school, he recalled a student opening the door for him and saying "here you go ahead." Actions like this were uncommon to Mr. Maple before coming to Orange High School.

The school environment is also attributed to the type of people that Orange High School brings into the building. According to Mr. Maple, "We have to go out and recruit teachers. When you go out and find good teachers with strong science backgrounds who really care about kids, then you can make it a department where kids want to sign up for classes, and kids want to come here." Orange High School has also had a large staff turnover in the past few years, which has allowed Mr. Maple to hire teachers who match his vision for the department — newer and younger teachers who will teach using the MI pedagogy.

Professional development at Orange High School's science department focuses on workshops for teachers who would like to implement the MI pedagogy in their classrooms. These workshops are also staffed by teachers from Orange High School who currently use it in their classrooms. As a foundation for all faculty members at Orange High School, Mr. Maple said, "Nobody is going to work in this department unless they have been to a Modeling workshop." Common professional development helps all faculty members share a common vision when approaching their instruction. Other professional development is offered, but "that is often flavor of the month," which Mr. Maple does not think works long term. "We feel like Modeling is not flavor of the month and is built to last. We have teachers who have been doing workshops for close to 20 years, so we have proof of that." Modeling workshops seem to be the only professional development Mr. Maple really cared about, but he also encourages his staff to take workshops in contents beyond what they currently teach.

Collaboration amongst teachers was another theme that became clear in the science department at Orange High School. When observing teachers in their classrooms, it was common to see other teachers inside the room asking questions and taking notes. This behavior is encouraged and practiced by Mr. Maple. "I think the nature of Modeling Instruction is that you cannot do it in a vacuum; it is just too hard." Teachers often share ideas on instruction, observe each other, and hold conversations, to try and find the best way to question students or fix common misconceptions. "With traditional instruction, you can make your PowerPoint for a lecture, do it, and then repeat every year for 20 years. It's just a lot easier than Modeling." Mr. Maple would like to see even more collaboration with his teaching staff so as to meet the needs of an ever changing student body, but thinks they are still doing satisfactory work.

Mr. Maple described the implementation of MI at Orange High School. MI began with Mr. Oak giving his students the Force Concept Inventory (FCI) and seeing miserable results. Mr. Oak was a proud teacher who won a Golden Apple and was named Physics Teacher of the Year. Based on these results, Mr. Oak flew to Arizona to take a workshop, which was about 25 years ago, then brought this information back to Orange High School. "Kids in groups doing presentations, paradigm labs, Socratic style discussions, and no textbook did bring some push back from some parents, but Mr. Oak had a stellar reputation as a teacher, so that gave him some political capital." After this initial experience, Mr. Oak was able to convince students, faculty, and community members that MI increased students' science skills and was a better technique for teaching science. The number of students signing up for Physics classes also increased.

Mr. Maple began working at Orange High School in 2002, but has history with Mr. Oak. Mr. Oak was Mr. Maple's high school physics teacher. At that time, Mr. Oak was teaching in a traditional format, but Mr. Maple still felt that he was one of the best teachers that he had ever had. "When I walked into his classroom here, I thought, "What the heck's going on? Why are kids in groups? Where's the textbook?" Upon deeper evaluation, Mr. Maple saw what he thought was fantastic, seeing students doing and saying things that he thought were beyond what he had previously seen. Mr. Maple then wanted to bring MI to his class, so he attended a MI Physics workshop over the summer and worked on ways to use the same techniques in a Chemistry class. He then met someone who introduced him to a Chemistry modeling workshop, and as a result he revised everything he used in his previous years of teaching. "I had been picking and choosing units, and it worked, but we would hit a high note with Modeling and then go back to traditional units, and the kids would ask things like 'When are we going to whiteboard.'"

Around that time, Mr. Maple became the department chairperson at Orange High School and got other Chemistry teachers to take MI workshops. Biology teachers then followed and took workshops to be trained in MI. Once all the science teachers were on board using MI, Mr. Oak suggested they begin hosting summer workshops at Orange High School, and Mr. Maple and the school administration supported this decision. "This process has been all bottom-up. In fact, there were some dark years where the administration was not very supportive." Individuals like Mr. Oak changed that "because people walk by his classroom and say, 'How do I teach like that, because I see it and I like it.'"

Silver High School

The science and technology department chairperson at Silver High School is Mr. Pine, who is in his fifth year in that role. He had previously spent nine years as a teacher and department chairperson in a different school district.

The community involvement at Silver High School is "strong on things they care about." Strong support on specific issues has been shown in both telephone calls to the school and votes for local referendums. Due to certain members of the community having stronger voices than others, the school has been trying to set up advisory panels where various groups could have representation and work with the school to meet the needs of all parties. "We haven't used them as well as we need to use them to make our programming better — basically tap their expertise and resources." The community has many successful doctors, lawyers, scholars, and others who can help contribute to the school, but Mr. Pine feels that that school needs to set up venues for that to take place. Some groups have become better at mobilizing as a group for the common good, such as the African-American demographic, which is a significant population within the building. Mr. Pine said, "Relative to other places I have been, they are doing a nice job of assembling into parental groups that provide us with feedback and push us to make sure we are keeping equity in the conversation."

In terms of science instruction, there has not been any backlash from the community, as MI is a choice for the students. The school has a traditional and MI sequence that the students can choose as they enter the building. Students can also change once they begin, but that does not appear to be a common occurrence. Community

members are given information on each sequence prior to registration, and over the past five years, the MI sequence has grown tremendously in terms of numbers. "The Modeling sequence has a reputation in the community, and the community speaks to each other and tells each other what it is." Mr. Pine also commented on the mixture of students in the MI sequence, as compared to the homogeneous groups within the tracks of the traditional sequence. "They range from our most touted student coming in, to a kid who is on the border of reading at or below grade level."

Mr. Pine describes his leadership style as "trying to empower teachers to promote change in the organization." This technique was evident with the way Mr. Pine interacted with the teaching staff and how he helped to implement MI within the building. He would often suggest that teachers try new strategies, rather than demand that something took place. "When I arrived here, we were a very teacher-centered building," and since that time, he has tried to provide examples of how the building could look differently. "Providing models for teachers to see other than what they are doing and doing it in a non-threatening way" is how Mr. Pine has went about changing the instruction. During TCT, Mr. Pine was observed going group to group, asking teachers where they were with their projects and then asking where he could help. His help included additional resources, brainstorming ideas, or anything else the groups wanted.

Silver High School is a large school with many different events throughout the year. Due to the resources available at the school, faculty and students can have access to any program they might want or need. Resourses, particularly financial, "are the biggest thing we have to acquire the people that we have here in the building." The ability to have multiple programs taught by an experienced, and often hand-picked, teaching staff creates an environment where students can flourish.

Having multiple programs in a large school with many resources does create some potential problems. When asked about the focus of the school, Mr. Pine responded, "Focus as a whole school? I'm not sure we have one." He went on to say that the struggle with having so many priorities is that the school has trouble saying "no" to any of them. In most cases, if there is a problem, the school will allocate resources and create a new program or initiative, which leads to having more programs than necessary. Mr. Pine also said that the practice of creating new programs is true of the academic course work in the building. "Heavy tracking has led to overtime, having a space for every type of kid. If you're not good enough for this room, we will create another room for you." The introduction of the MI sequence in science was designed to change the homogeneous student populations created by tracking. This sequence has all students, including honors students, in the same heterogeneously mixed classroom.

Collaboration is an area where Mr. Pine has noticed much growth since taking over the science department at Silver High School. "About five years ago, it was rough. It was competitive." Teachers, at the time, were competing with each other for attention, which lead to resentment by some staff members. Introduction of TCT teams and the MI sequence, under the leadership of Mr. Pine, has changed that environment to one where open sharing and common planning was evident during observations.

Professional development is done inside the TCT and is available to teachers upon request. Due to the available resources, professional development is made available to

meet almost any teacher need. All teachers who teach in the MI sequence have attended a two-week summer workshop. "The teachers who teach in the Modeling sequence have agreed that they will take the training. I do tell them before I schedule them, so there is that expectation." Outside those expectations, teachers just need to do whatever professional development they are required to do to keep their license valid.

MI was brought to Silver High School by Mr. Pine. When he took over as the department chairperson, the school had an Integrated Lab Science (ILS) sequence, which began with 150 students as freshman, but went down to about 50 students enrolled by junior year. "We were losing kids out of that sequence, and part of that I think had to do with the staffing. I think the curriculum too." Mr. Pine was given the choice to improve the ILS sequence or get rid of it. Having used MI at his previous school, he decided to use MI as the framework for a Physics first sequence. This sequence would be open to any student who enrolled; honors credit would be open to any student, but the earned honors credit would be based on completion of an additional research project.

In the five years since ILS was changed to a sequence of MI, Silver High School has seen the numbers grow. Increased student numbers in MI classes have required Mr. Pine to ask more teachers to attend training over the summer. Teachers seem to enjoy what they have seen in those first few years, "so it's not a difficult conversation." Reactions from the students, by selecting the sequence during registration, "has grown from five sections to 11 sections." The growth in number of students taking the sequence has also helped to support it in the eyes of teachers and administration. "There's been no outrage about it. I think the fact that we made it a choice has really helped us with that."

Teachers

Orange High School

Five teachers were interviewed at Orange High School. They ranged in experience from a second-year teacher to a 41-year veteran. Representatives from Biology, Chemistry, and Physics were all interviewed, and classrooms were observed to see the instruction and interaction with students.

Community involvement is something that is vital for successful schools. Most teachers at Orange High School were proud of the community support. When asked about community involvement, Mr. Oak said, "It's very strong with a lot of support of both families and community for both academics and extracurriculars." Mr. Birch added, "There's a high level of support. Parents do a lot to support the school. There are community groups who come in and give talks, act as speakers, and those types of things." Not all teachers had the same opinions though. Ms. Apple and Ms. Plum identified that high-level (honors) classes have great involvement, but in lower-level classes that contain more minority students, the parents are harder to contact. "I always hear these great stories; they send out newspaper articles each week about what parents are involved, so I know there are parents involved, but in terms of what I see, I don't really have much involvement with parents," according to Ms. Apple.

When it comes to making decisions for the school, the community chooses to be active members in the school. "Parents have been very interested in our methodology in teaching, and invest some really good questions during our curriculum meetings and things

like that," according to Mr. Oak. Much like the administration, the community is supportive rather than demanding. As Mr. Aspen put it, "Our parents have been really supportive." When parents do have questions, they are often just looking for clarification. According to Ms. Plum, "At times there will be pushback, but once you explain where you are coming from, then they seem to buy into the process." This dynamic also seems to be another layer of keeping the staff accountable, while still maintaining a supportive environment.

The leadership at Orange High School is present by making frequent visits to classrooms. All five teachers stated that Mr. Maple was in their class on a regular basis, about every one to two weeks. Teachers did say that it varied depending on a variety of factors, such as which course is being taught, evaluation years, and other factors. Commenting on visits from school leadership Ms. Apple stated, "On years that I have to be observed, a lot. On years where I am not observed, not nearly as much." Visits by Mr. Maple did seem to be more frequent than drop-in visits from other administrators. Mr. Oak said, "Mr. Maple stops in once a week, and visits by other administrators are less frequent." Mr. Birch had similar statements about classroom visits from leadership. "As a tenured person in a non-evaluation year, I would say Mr. Maple is in once every other week. No one else in the administration has been in my classroom."

Leadership at Orange High School monitors the current practice, rather than just making changes or demands. "They let us do what we need to do in order to teach our kids the best way we can," was how Ms. Plum described the building leadership. Mr. Aspen described the leadership as "more hands-off, letting us do what we think is best as educators." Teacher autonomy and trust was a common theme, but at times, directives do seem to be given to keep everyone moving towards the same goal. Mr. Birch stated, "I would call it a combination of top-down and bottom-up. I think there is a decent balance of allowing teachers' autonomy and making decisions. At the same time, having some directive when they feel like it is necessary." Allowing for decisions to come in both forms keeps a balance of power between the staff and administration.

Decision making by the leaders and followers in a group allow for all voices to be heard, and allow all stakeholders to feel like part of the organizational process. Mr. Oak said, "What I like most is they treat us like professionals. Here in science, when we say we have a methodology or pedagogy that we should follow, and we have research that backs it up, they let us do it." He did note that the leadership did expect there to be some research or data to prove the method was valid before accepting the faculty's decision. Mr. Aspen included, "There is definitely some oversight and accountability, but we get the freedom to teach the way we think is best for our students." Leadership again allowed stakeholders to be part of the process, but had the oversight and final authority when needed.

While not making authoritative decisions all the time, the teaching staff did talk about the supportive nature that the leadership gives them. "Anything that I've asked for I've gotten," declared Mr. Aspen when asked how the administration has supported his teaching. Open conversations were another item that was mentioned by Ms. Plum as a way to help her improve as a teacher. She described teaching Physics for the first time and having the ability to go to Mr. Maple to talk or observe his class to get a better idea of what she should be doing. "If something is a problem or something went well, I can express

that." This kind of support and trust leads to a teaching staff who can ask for help and continue to grow and push each other.

A leadership split was apparent between the building administration and Mr. Maple. Though both were in leadership positions over the teaching staff, Mr. Maple did seem more hands-on in terms of the day-to-day operations of the science department. Building administration did not seem to be as involved and used Mr. Maple as a liaison between the teaching faculty and themselves. This dynamic gives Mr. Maple an ability to shape the department from the inside, as he also teaches science classes.

Orange High School is a school that is changing and becoming more diverse. "We have students right across the street that live in million-dollar homes, then we have a large population of students that are low income and on free and reduced lunch," according to Mr. Aspen. This range of students is something that school personnel are aware of and are making changes to accommodate this shift. "Kids are becoming more diverse; in terms of socioeconomically, ethnically, our school is changing a bit, and we are trying to adapt to the changes. I think the other stuff is changing faster than we are," said Ms. Apple, describing the school's response to their current changes.

Continued support for students is one way the school has adapted its environment to help all students meet the expectations the school has for them. Mr. Birch described the school goal as "the slogan is Tigers are 100% for 100%. I think the expectation is learning for both teachers and students. From the administrative standpoint, they want teachers to do whatever they can to help kids learn, and they also want students to understand that learning falls on them." Ms. Plum added, "It is really all about improving; it's not about we had a benchmark, we're done; it's all about how can we continuously get better."

Teachers also support each other as they work to make science goals attainable for all students. "There's no problem sharing; we have a PLC team and there's a lot of sharing there. Overall, we're trying to help the most amount of kids that we can," explained Ms. Apple. PLC groups have been helpful in building a venue for that type of improvement. "It gives us more time to talk about what works well and what doesn't. We share data sometimes to see what we can improve," explained Mr. Birch on how the school environment really encourages all stakeholders to support each other for the best possible outcomes. Teachers not only use dedicated time to align teaching and learning goals with each other. Mr. Oak stated, "When we sit down with our colleagues, weather at lunch or other times, we have a common language that we speak."

Pushing everyone towards success also comes with the school maintaining the rigorous standards for students in science classes. "Academically we want students to be critical thinkers and problem solvers," said Ms. Plum. "We don't want to send kids out of our classrooms that still have misconceptions," she continued. Expectations "are becoming more rigorous," as Ms. Apple put it, but school staff also tries to provide supports for students who struggle.

Collaboration is obvious when walking through the science department at Orange High School. During classroom observations, some teachers spent their preparation period in their colleague's classrooms. This common practice is encouraged by building leadership, helping to provide dialogue amongst the teaching staff. Teacher interviews

were interrupted as other teachers were continuously stopping what they were doing to help a fellow teacher.

PLC time is built into the schedule, which allows teachers to access each other and discuss their practice. Mr. Oak mentioned that having all teachers use the MI approach allows for the conversations to be productive since "we have a familiar language, mindset, and approach." He later explained that they are not just spending meeting time debating ideas; they can focus on the exact components of the lesson or activity and specific techniques that worked or did not. Other teachers shared similar viewpoints in their assessments of PLC time and collaboration. Ms. Plum simply stated, "In the chemistry honors level, we have a really good PLC."

Professional development is another area where the science department makes sure they all have the same foundation. As stated by faculty at all levels, all teachers take a MI summer workshop before they begin teaching at the school. Taking the MI workshop helps to ensure that the new teachers have the same familiar language and approach as previously mentioned by Mr. Oak. Other professional development is the teacher's choice, but most continue to work towards some skill or knowledge. "At other schools I've been at, summers were just off time, but here, pretty much everybody is doing something during the summer," according to Mr. Oak. Mr. Birch discussed "Tiger tours," where teachers could sign up to see another teacher's classroom when a specific techniques or program was being used.

MI was introduced to Orange High School by Mr. Oak. According to his recollection, he began in 1995 after taking a workshop, which was taught by Greg Swackhammer at a local university. He found the MI workshop through an advertisement in *The Physics Teacher* and thought he would try it. "That first semester of that first year was really bad," recalled Mr. Oak. "I realized that I really underestimated what kids could do." He continued to use the method in his classroom, and the school noticed a jump in Physics enrollment, which meant hiring another Physics teacher. Mr. Spruce was the teacher hired, and he enjoyed seeing what Mr. Oak was doing, so he also took a workshop. Physics enrollment continued to increase, as did enrollment in science as a whole. As a result, more and more teachers began taking workshops.

Administrative support did help with the implementation. Since taking over as the department chairperson Mr. Maple made a push, ensuring that everyone who teaches in the building has been trained in MI. Outside the initial implementation, administration does support teachers in their pursuits by hosting summer workshops for MI each year. Mr. Oak, Mr. Birch, Mr. Maple, and Mr. Aspen typically will teach the workshop session for teachers from various school districts. Mr. Aspen noted that implementation "hasn't been pushed upon anybody; for the new hires, it is encouraged, but for the people who've been here, it's not a mandate." Ms. Plum added, "We have another high school in the district that does not do Modeling. Our administration supports us and their administration supports them."

Silver High School

Silver High School allows students to take all of their science courses in a traditional sequence that is tracked by test scores/ability or a MI sequence where all students are intermixed within the class. Six teachers were interviewed, and they ranged in

experience from a second-year teacher to a 17-year veteran, who was one of the more experienced teachers within the department. Representatives from Biology, Chemistry, and Physics were all interviewed, and classrooms were observed for instruction and interaction with students. Some teachers taught classes in both the Modeling and traditional sequences.

Both parental and community involvement help make schools successful. Silver High School staff described the community involvement with a wide spectrum. Teachers who have taught at other buildings were very positive. Ms. Cherry described the community involvement as "through the roof," and Ms. Pear said, "There's a ton of parental involvement, which is very different from where I was before." Mr. Elm, who lives in the community, added, he feels the community is very actively involved, not only with the school, but with all aspects of things that take place, extracurriculars, athletics, fundraisers, etc. Mr. Hickory gave a perspective that parental involvement was dependent on the level of class that was being taught, with higher-level classes leading to more involvement. "In my lowest-level classes, on parent-teacher night, I might have one parent, where in an upper-level class, I might have 40 parents come in," said Mr. Hickory.

Community involvement in decision making was something that the teachers discussed. Mr. Willow, who lives in the district, mentioned the high taxes that community members pay as a reason for them wanting to have a voice at the school. He also mentioned that this voice may not always be representative for the entire school, but only those who have already achieved some success. "Sometimes the community involvement can lead to some of the issues we have had, such as the stated equity piece of it, because the people who represent the community may not have all the students in mind at all times," said Mr. Willow. "Mainly just the ones who've already achieved success, but overall, I would say it's pretty good." Ms. Cherry discussed the two sequences offered at the school as being a way to allow community members to pick how they want their children to be taught. "I've taught honors biology and modeling physics, which are essentially the two choices that kids are offered. Do you want to take honors biology or modeling physics or do you want to take CP (regular level) biology or models?" Mr. Hickory described the influence of certain upper-end parents by saying, "This community, especially at the upper end, is just playing a game," where they know how to use the system for their advantage and take every opportunity they can get.

Equity within the community was another area where teachers mentioned some major difference, with the more affluent parents getting more of what they want, and the lower income parents just trying to figure out how the school works. Mr. Elm stated, "I do get the vibe that some parents think that this place can be a bit intimidating." Mr. Willow added, "I think the community has been really supportive, but maybe for selfish reasons," describing how the community does realize the impact that a quality school has on other community factors, such as land value. Parents were described as everything from "helicopter parents" by Ms. Pear, to "limited" by Mr. Hickory. The split between involvement and student placement was apparent from the interviews with the teaching staff.

Presence inside the classrooms was something that the leadership at Silver High School did not emphasize. Aside from Mr. Pine, most teachers said that a member of the

building administration did not visit their classroom. "I would say that our administration is pretty hands-off when it comes to the actual classroom," described Ms. Mango. Mr. Elm put it as "not often and almost never" for the administrative team other than Mr. Pine. Ms. Cherry went on to say that in her two years at the school, she does not have a sense of the upper administration, due to limited contact, but has heard "both good and bad" things about them. The overall theme sensed was that the building and district administration are spending their time with other administrative duties and not inside the classrooms. Mr. Pine was noted as being more present inside the classrooms, but due to his teaching schedule, it was often mentioned that he is in classes more often when he shares a room with that teacher. It was also mentioned by Ms. Mango that "Mr. Pine teaches the same class periods that I teach, so he doesn't get to walk in there as much," which shows how his role as a teaching department chair could inhibit his leadership roles.

Despite not being in the classrooms on a regular basis, the building leadership was still described as supportive, but in a hands-off type of way. Most of the leadership focused on Mr. Pine, since the interactions between the science staff and other administration were described as limited. "Mr. Pine is really supportive with new ideas and also helps us a lot when we try something new," according to Ms. Mango. Ms. Cherry added, "Mr. Pine treats us as individuals and tries to get to know who we are and what our individual needs are," showing that he is looking to help each teacher grow in the direction they want to be headed. Ms. Mango added, "He [Mr. Pine] doesn't micromanage us, so we can go see him, and he seems to have our back if there's a problem."

Decision making is done at multiple levels, with Mr. Pine controlling more of the day-to-day leadership, and the central administration focusing on school and district policies. Ms. Mango mentioned that Mr. Pine was in a different category than central administration, who occasionally make the "top-down blanket decisions." Mr. Hickory had similar thoughts, describing Mr. Pine as "amazing at pushing teachers towards a better way of teaching, without being heavy handed," and always inspiring them to do better. He described the central administration as not making any sense. He said that he "understands that they have external pressures and compliance issues to worry about, but still cannot figure out why they do what they do." Mr. Willow added that even though the central administration does make decisions, they typically do not affect his day-to-day operations as a teacher. "I never felt that I was a puppet," said Mr. Willow. "I can just always do what's best for the kids."

Upon walking into Silver High School, one noticeable characteristic is the diversity amongst the students. The school has multiple ways that they have attempted to include diversity and achievement in the classroom, and they seem to be continuing to try new programs and course options to meet these goals. "There's a big achievement gap between students of color and white students, so that is something that we hear about all the time," according to Mr. Willow. The tracking system that is used tries to allow each student to be in a supportive environment, but this same tracking system sometimes comes at a loss of the school's diversity. "I teach reluctant learners and struggling learners in three sections. In those classes there are definitely more minorities, more Latino and African-American students," Mr. Elm said. He then went on to talk about his MI sequence courses where "those classes are a bit more integrated it seems racially," which is something Mr. Elm

feels benefits the students and the school. Ms. Cherry described her role in the school's equal opportunity team, which is trying to increase the number of underrepresented students in AP classes. She then went on to share similar feelings about the inclusive nature of the MI sequence. "Depending on the track and the coursework that students achieve," she says, "I think that's what's been cool about models is that we have a truly mixed class, so we've been able to see that."

Rigor for all students was another hallmark of the school, provided from the perspective of the teaching staff. Mr. Willow said, "Overall, the expectations are very high." Ms. Pear made similar comments, but added, "because of tracking, we probably have some students who may be held to a higher standard, but we try to get everybody to level up and reach their potential." Ms. Mango said the rigor is based on the idea that "most teachers believe that our students will go to a four-year college." Ms. Cherry did say that the standards are not always as high in all places. "It varies from class to class and student to student." Overall, it seems that Silver High School is pushing students towards challenging standards, but still has some places where the standard may be slightly lower.

Support for its students is one way Silver High School is taking a diverse group of students and having them meet challenging standards. One way the school is trying to meet the demands of these diverse needs is with multiple levels and multiple class choices, including how students would like to be taught, by allowing them to choose their science sequence. "We provide a lot of different choices for students," said Ms. Mango. "I think that if their interests are attended to, then we should be able to expect that they are going to achieve, because they should be engaged in what they are doing." Ms. Cherry mentioned the supportive teachers in the building. "I've come across very few teachers, and heard very few stories of teachers, who are not doing great things for kids. I think that makes a huge difference." Mr. Hickory made reference to the community support by saying, "We come from a town that is willing to invest a lot in their kid's education."

Teachers also seem to get similar levels of support in their quest to educate the students of Silver High School. Ms. Mango discussed how the teachers at the school are able to reach students by always looking for new ideas, and the "support from parents and administrators to continue to be innovative" has helped students get the best teaching possible. Mr. Willow also commented on the "resources" available to the teaching staff, staying up-to-date or learning any new techniques, as something that makes this school different than his previous schools. Having a large collection of dedicated teachers seems to support itself. Ms. Pear described it as "a much more positive environment" than other schools where she worked. She then followed up with, "I feel like I'm in a department where we just talk about science and how we can teach it better." This dynamic makes it where teachers can have the support they need at any time just by walking into the department office.

Collaboration takes place informally by teacher conversations, and formally during scheduled TCT (their version of PLC). Frequent informal collaboration was mentioned by all interviewees. Many mentioned the large number of teachers in the department as a helpful aspect to collaboration. Mr. Willow described a former school where he was one of 10 in the entire building, including the middle school, and where he now is in a room that he shares with nine other teachers. He also mentioned the attitude where "no one's been

closed off in terms of helping or sharing or allowing you to watch." When asked about what makes the school successful, Mr. Elm responded, "As a department, we collaborate as much as we possibly can." Formal TCT was just as dynamic. Observations of TCT saw groups of teachers spending two hours engaged in discussions and working on projects, but all centered on improving the educational experiences of students. Teams also worked on presentations of this year's accomplishments to share with the entire faculty.

Professional development is partly done in the TCT groups, but it is also done on an individual, as needed, basis. Ms. Pear described the TCT professional development as the staff working on learning strands. The learning strands cycled by topic and year, but gave examples of social-emotional learning, racial equity, and literacy. Ms. Cherry was "amazed at how much professional development was integrated into the school calendar." Individual professional development is done through teachers applying for any professional development that they would like to attend. Mr. Willow stated, "Everything I've ever asked for, I've gotten." He also described how the district offers additional pay and travel expenses to encourage teachers to go to training. All teachers described the individual professional development as something where they can attend anything they want, and the school makes it possible for them. Examples ranged from the National Science Teacher's Association (NSTA), to Google app training, to AP and MI workshops.

MI was brought to Silver High School out of a need to replace a science sequence, Integrated Lab Science (ILS), that was losing students each year. Around that time, Mr. Pine came to the school as the science department chairperson. He previously used MI at a different school district and thought it would be an ideal replacement that would keep the core inquiry components of the ILS sequence for the students. Mr. Pine went to the central administration and the Board of Education to propose the changes in the course, according to Ms. Mango. Mr. Pine then asked Ms. Mango if she would be willing to try it. Ms. Mango taught it the first year without any training. "We followed the curriculum, and then after the first year, I went to the workshop at Orange High School. In retrospect, I am actually glad that I was in the classroom for the year prior, because at the workshop, I had better questions to ask." That first year, they both taught Physics with incoming freshman.

Following the initial year, Chemistry was added, and Ms. Mango began teaching the Chemistry classes. Growth in the program meant Silver High School would need more teachers to teach the courses and more teachers to attend the trainings. Mr. Pine then asked if teachers were interested, and Mr. Willow asked if he could go. "I saw what they were doing, and it looked interesting," said Mr. Willow about his decision. The other teachers all began teaching in the MI sequence and attending the training based on conversations they had with Mr. Pine, where he encouraged them to become part of the team. Ms. Cherry was an exception, because as a new hire, she was asked to attend the training at her interview, as Models of Biology would be one of the preparations on her schedule. Mr. Hickory was the most pessimistic of all the teachers interviewed and only taught a section of Models of Physics based on need. "I was nervous, but it's been very awesome," admitted Mr. Hickory.

Themes

Identifiable themes from the interviews were found, each having specific nuances that allowed change to occur in the manner it did at each of the two schools. Similarities were found at each school, and common themes were present between them. These major themes were present at both schools and mentioned across all levels building leadership and teaching staff: (a) professional development, (b) collaboration, and (c) support. These three themes emerged as tools that each school has provided as a way to make this change successful.

School leadership did not directly address the next theme of transformational leadership, but the leadership style was evident by comments that were made by the leadership and supported by the teaching staff. Transformational leadership has many components, such as the four I's, (a) individualized influence, (b) inspirational motivation, (c) intellectual stimulation, and (d) individualized consideration which were identified during observations as well.

The final theme that was present at each school and noted by the teaching staff, but was not mentioned at the highest level of administration, was common language and beliefs. While teachers discussed this topic, it was also a theme that administration gave time for and seemed to encourage.

Each of these themes appeared throughout the interviews at both schools and were identified as major components in the leadership styles, processes, and structures that have allowed successful use of MI in science departments at secondary education buildings.

Conclusion

Implementing MI in the science department at both Orange High School and Silver High School took time to have all stakeholders take ownership of it. Characteristics, such as a supportive environment and community, also helped with this transition. Leadership, the department chairperson in particular, created an environment of collaboration and risk taking, allowing the teaching staff to feel comfortable in making a shift within their classroom environment. Administration also provided support with training and professional development, allowing the vision of these two department chairpersons to come to fruition.

Chapter 5: Analysis & Discussion

Introduction

This study examined the leadership styles, processes, and structures that have allowed successful use of Modeling Instruction (MI) in a science department at a secondary education building. Interviews and observations were conducted at two schools with administrators, the science department chairpersons, and multiple science teachers. Observation data was noted, and interviews were transcribed to identify the themes that were present at each school. Results obtained at both schools were similar; **the major themes that emerged were (a) support, (b) collaboration, (c) professional development, (d) transformational leadership, and (e) common educational philosophy.**

Analysis

Themes identified from the interview data showed that leadership helped the transition to MI by providing support, professional development, and opportunities for collaboration. These factors helped the faculty become familiar with the new techniques and teaching pedagogy, while allowing them time for discussions and the ability to learn from their mistakes.

Support

Support for teachers by the building leadership was an evident theme within the data. Based on the responses of the school leaders, offering support to the faculty was something they ensured they were doing. School administration at each school discussed their role as "being a coach" or "a teacher leader" to describe the way they go about their work. Relationships with faculty were also mentioned as a critical piece. Ms. Apricot stated, *"It's all about relationships for me. I think that's the key."* She then went on to elaborate the need for solid relationships and trust if she is going to ask teachers to do something they have not done before. Mr. Fir said, *"I think of myself as a teacher, even though I'm not currently teaching any classes of students,"* to demonstrate how his mind always thinks from the teacher's perspective. Mr. Maple discussed how he tries to support his staff in any endeavor that they choose. *"I want this [science] department to look forward to coming to this building every day. I feel if I can figure that out, everything else will fall into place."* Mr. Pine showed similar beliefs in supporting his staff in making large organizational changes by using the phrase*, "Trying to empower teachers to promote change within the organization."*

Teachers also identified the support they were given by their leadership. Mr. Aspen described his leadership as being *"very supportive of what we do; they're definitely allies in everything that we're trying to accomplish up here."* Similar feelings were expressed by every teacher who was interviewed. Ms. Mango summarized her school leaders as *"really supportive with new ideas."* She also said Mr. *Pine "helps us a lot when he wants us to try something new."* She later added that the whole teaching staff feels comfortable asking for more support if they need it. Mr. Elm summarized the leadership style *with "They offered assistance, advice, and resources whenever asked."* Teachers also mentioned the ideas of

relationships and risk taking as things the school leadership has encouraged, and as things they think helped with the change to MI. Ms. Plum stated, *"I would say schoolwide it's building relationships,"* as the focus from her administration. Mr. Oak added, *"There's a really strong push for us to build personal relationships."* Ms. Cherry stated, *"We've been able to form relationships with science mentors outside the school who can help our kids do honors projects through the modeling curriculum,"* as a way that they have been put in contact with others who can help meet the needs of students.

Support for teaching staff was also seen at both schools during in-building observations. At Orange High School, Mr. Maple could not walk down the hall without stopping to answer a question or check in on a class. During a visit to Mr. Oak's class, he asked a young teacher who was observing Mr. Oak how the class was going, if she had any questions, and if there was anything else he could assist her with while she was in the building. Mr. Maple also stopped in two other classes during that trip down the hallway to ask the teachers if they needed anything and to pass along reminders to them. Silver High School had similar experiences where Mr. Pine was assisting the entire science department during their common plan time. He was observed helping groups while in the room, but also running to the office or other areas to get supplies or answers to questions the teaching staff had proposed.

Collaboration

Collaboration was another key theme that was mentioned across all levels at both buildings. This characteristic seemed critical for the members of the science departments in order to undergo a complete shift in pedagogical framework. Leadership at both buildings provided time to allow collaboration to occur. Time for collaboration included department meetings and **Professional Learning Community (PLC) time (called TCT at Silver High School).**

The use of PLC time was mentioned by all teaching staff as something that helped with the transition to MI and the continued success of their instruction. Mr. Birch stated, *"We've also had PLCs for the last three or four years, and that I think has helped, especially within content areas."* Staff at Silver High School were observed making presentations of what their TCT groups accomplished during the year to share with the rest of the school. Staff at both schools mentioned the benefits of this time to align materials, discuss techniques, or think of new ways to reach students. *"A lot of times our professional learning community allows me to meet with physics; because I have three classes of physics, we all share resources so we're on the same page,"* Ms. Plum stated. Ms. Apple described her team, *"We're pretty close to the team and we share. There's no problem sharing, we have a PLC team and there's a lot of sharing there*." Mr. Aspen mentioned the constant talking of the physics PLC team as a way to show the collaboration amongst the group. He went on to talk about the benefits. *"We do everything that we can to help each other out to put less work on one person."* Mr. Aspen then went on to discuss the competitive nature of other schools, where teachers want to be better than each other, which he feels takes away from Orange High School's goal of collectively being the best they can be for the students they serve. Ms. Mango added that the collaboration also goes beyond the MI group. *"I teach models of chemistry, and Mr. Evergreen [AP Chemistry teacher],*

Mr. Willow, and I will talk about the topics that we're working on an ideas that we come up with for demos or labs. We talked about how models could benefit from AP and how AP can benefit from models," she said.

Outside designated PLC time, teachers at both schools discussed informal collaboration as something that has helped with the transition to MI. Mr. Hickory stated, *"We talk every single day,"* to show how often teachers were exchanging ideas. Leadership at both schools did encourage this type of dialogue and felt as if using MI has reinforced the exchange of ideas between faculty members. Mr. Pine stated, *"We had a very competitive environment when I walked in; not only were teachers competing with each other for attention, but there was also resentment amongst different individuals within the staff. The modeling thing helped us to get to where we are now because it started to create models of what true collaborative teams do."* Teaching staff agreed with the importance of collaboration. Mr. Aspen spoke about having different schedules this year, which made collaboration more difficult. *"So we set up times to meet for that [collaboration]. In some schools, it's more of a competition, where everybody feels that they have to do as much as they can to be the best, so they don't want to help each other out."*

Collaboration was observed, as well as reported, at each of the school visits. During the observations at Silver High School, the collaboration was seen both formally during their TCT and informally in office conversations. TCT was a whole group sharing ideas, where collaboration was occurring mostly in subject teams, but did have crossovers. For example, teachers in the MI sequence and traditional sequence got together to discuss how each group covered genetics. This collaboration time provided the opportunity to see the staff work together and see Mr. Pine probe the groups for more thought and/or deeper reflection. Informal collaboration was seen throughout observation and interview time, as staff would talk about what they were teaching in the various offices of the school. When it was time for interviews, Mr. Elm and Mr. Hickory were observed discussing the lesson on energy and student responses they had in class. This informal collaboration was also witnessed at Orange High School, where teachers would use their preparatory period of time between classes to ask a quick question or exchange ideas. Mr. Oak was seen being observed by a teacher in order to help her with teaching Physics for the first time. He was also seen having conversations with Mr. Aspen about the lesson of the day and how to shift the planning for the rest of the week based on the responses of their students. This type of collaboration seemed to be evident at each school and falls in line with the collaboration discussed at the MI workshops, as well as the teacher interview responses.

Professional Development

Professional development was necessary for the initial change to MI, as workshops were used to introduce the teaching staff to the methods and pedagogy. Mr. Maple bluntly stated, ***"Nobody is going to work in this department unless they have been to a modeling workshop, and most often, they go to more than one."*** He later stated that he encourages more than one because there are subtleties that can be missed the first time. Ms. Cherry reflected on being told by Mr. Pine that she could attend a workshop now or the next summer, but would have to attend one to get the job. Teachers at both schools described

the workshops as beneficial, having the opportunity to take on both student and teacher roles to familiarize themselves with both sides of the classroom. Mr. Aspen described the workshop and professional development as, *"Getting to take workshops and getting to work with people like Mr. Maple, who is not my content, but is a great educator, or other teachers, to just listen to what happens in their class and have conversations with them."* Mr. Birch stated, *"I just had to think a little bit more about the big picture and how to make the connections, or how to get the students to make the connections between the content and topics we're doing."* Mr. Oak mentioned how the workshops changed his view and his role of teaching. *"I realized that I really underestimated what kids could do. I always thought, 'I have to do this for them,' because they will never figure it out, and they can figure it out."* Ms. Mango described her introduction to the MI workshop as, *"We followed the curriculum modeling instruction, and then after that first year, I went to the workshop at Orange High School with Mr. Oak and loved it."* Ms. Plum commented on the MI workshop and the firsthand experience needed to understand the methods. *"They tell you what modeling is, but you really don't have a sense of what it is until you're actually in the workshop or you're in a classroom and you've seen it."* Besides the MI workshops, both schools did offer some professional development at in-house meetings and institutes. Both schools also encouraged other professional development, but it was based on teachers approaching the leadership with ideas of what they wanted to attend.

Common Educational Philosophy

Due to leadership's ability, all faculty members at both schools who are teaching modeling courses adopted the same common educational beliefs for how students should be taught. Mr. Oak described this commonality as, *"We are extremely fortunate here because we do the modeling methodology. We have a familiar language, mindset, and approach."* He went on to discuss how having a common framework, is able to focus the faculty conversations on what students need to know and how to best accomplish that goal. *"This allows us to throw ideas back and forth about our approach to teaching,"* said Mr. Oak. Ms. Pear shared similar thoughts, *"I feel like I'm in a department where we just talk about science and how we can teach it better."* Mr. Elm elaborated on one of the benefits he saw from leadership's common beliefs by saying, *"Mr. Pine does a great job of cutting to the chase and focusing on what's relevant to our teaching and to our students and their learning."* Instruction and practice of these common beliefs of classroom dynamics, as well as the roles of teachers and students are something that takes place in the MI workshops. Common beliefs helped with the shift to MI, but the MI framework provided a platform to establish new routines for all teachers and students, which has allowed for continued success for the science departments. These routines have become part of the organizational fabric of each school.

Observation of beliefs was something that may not be able to be seen directly, but was seen indirectly by the way in which teachers ran their classrooms. Observations of both Mr. Oak and Mr. Maple at Orange High School, and Ms. Mango and Mr. Elm at Silver High School all demonstrated a similar classroom environment. In all four classrooms, students were presenting their findings on whiteboards and answering questions from other students in class. The teacher in each room acted as a facilitator, who seemed to only

interject when the discussion stalled, and then asked questions, rather than presenting information. All four classrooms had students grouped together, allowing them to work as teams. In each room, the majority of time was spent by students working together, rather than a teacher standing in the front of the classroom. Observing very similar classroom dynamics in every class led to the idea that the teaching staff must have similar beliefs in terms of what they consider to be the best way to educate their students.

Transformational Leadership

Individual capacity and collaboration, with the support of leadership, was evident by the observations and interviews at each school. When describing their own leadership style, building leadership used terms like coach, mentor, support, and model to describe what they do for their staff. Teachers also mentioned the same themes when describing their views of their building leaders. Statements of trust and encouragement were made in some degree by all teachers, along with the idea of being treated as a professional. Ms. Apple described the approachability, flexibility, and openness of the school administration as key factors in the success of the school. Ms. Mango added, *"A lot of support from parents and administrators helps us continue to be innovative."* This was one reason why she believes the school is successful. Ms. Plum stated, *"They trust that we're doing the best for students."* Mr. Aspen added, *"There's definitely some oversight and accountability, but we get the freedom to teach the way we think is best for our students."* Ms. Pear had similar sentiments about Silver High School. *"I think there is a lot of autonomy in the school,"* said Ms. Pear. Ms. Cherry expanded upon the pursuit of growth encouraged by her leadership and how it compared with a previous leader by saying, *"Compared to previous department chairs I've worked with, he's [Mr. Pine] far beyond what I've been around, in terms of making the interaction with you personalized and being helpful in you modifying your practice. Especially being a new teacher, that is something that I wanted early in my career and didn't get it."* Support and individual development for the betterment of the organization was something was clear from the data by all levels at each school.

Leadership was also observed as Mr. Maple and Mr. Pine walked the halls and into classrooms with the intent of motivating staff and inspiring thought and reflection. Mr. Maple was observed congratulating both teachers and students on previous accomplishments. While sitting in the office at Silver High School with Mr. Willow, Mr. Pine arrived and asked Mr. Willow about a new way to teach Physical and Chemical changes. Mr. Pine asked Mr. Willow to "think about it," then left, which is what Mr. Willow did as the interview began with a brief discussion on the topic of teaching types of changes in his Chemistry class. Witnessing this simple conversation was one way in which Mr. Pine caused deeper thoughts and reflection by Mr. Willow, without demanding or threatening that something should be taught in a certain way. .

Discussion

School transformation is difficult in any area, as teachers, students, and other stakeholders must adjust to something that is different from their routine. Changes in curriculum and teaching methodology are no different. Many times, this shift relies on both

teachers and students being supported while making mistakes during this transition period, as both need to learn the techniques associated with their new roles (Marbach-Ad & Hunt Rietschel, 2016). The change of the science departments at two secondary schools from traditional instruction to MI was no different. The leadership at both schools helped to ensure the transition was comfortable for all stakeholders. Mr. Pine, department chairperson at Silver High School, summed up the transition as*, "When I got here five years ago we were very teacher-centered in the building and in our division as well. We had the opportunity with the modeling thing to provide an example of our vision of how it could be different."* Leadership who support and empower their staff typically have higher levels of trust (Daly, 2009). Increased leadership trust allows for greater risk-taking by followers (Nienaber, Hofeditz, & Romeike, 2015). Building administration built trust and fostered positive relationships with staff, according to Ms. Apricot. *"For me, when you have these relationships and trust one another, then you're willing to try things and take risks. It also helps with collaboration, which makes leadership work,"* said Ms. Apricot. Mr. Maple added, *"When you have that kind of freedom in trust, you can build something really good."*

Making a change to MI or the way in which teaching science takes place involved a tremendous amount of risk on the part of the teachers, who were using an instructional method that was different from what most of them learned in their teacher preparation programs. In order for this change to take place, the teachers needed to believe that the leadership would allow them to make mistakes as they became comfortable with the new approach. School leaders evaluate teaching staff, so trust must be present for teachers to know that mistakes made while trying something new would not negatively impact their jobs. Ms. Pear felt the support of her administration and was not worried about trying something new. *"They trust that we're doing the best for students first with modeling, so they can be really lucky to be here in that case,"* said Ms. Pear. Relationships between those involved in the change and those promoting it are important for a successful long-term change, where all parties remain content in the years to follow (Venance, LaDonna, & Watling, 2014).

Positive relationships were also mentioned, as a result of the school leadership providing support to the teaching staff. *"I feel that I can go into Mr. Maple's office any time I want"* said Ms. Plum. *"If something is a problem or something went well, I can express that. I think that's been very helpful in terms of helping me improve as a teacher."* Mr. Willow said*, "I've always felt supported with it [MI]. Then with him [Mr. Pine] providing resources and anything we've asked for, it has never been a problem, so that has always been good."* Support and positive relationships with building leadership was a key factor in allowing teachers to be comfortable with a new pedagogy and with getting the resources they needed during the transition and beyond.

Providing examples for the faculty to see how the change would affect their practice, and by providing answers to their questions are other ways in which school leadership supported the changes to MI. During the MI workshops, teachers described having the opportunity to play both the role of the teacher and the student, which allowed them to see both sides of the classroom dynamics. Mr. Aspen recalled a story from his first MI workshop,*" It was my first day out there where I had to present a whiteboard and a*

force diagram that I had 'mg' written on my force diagram. They asked 'What's 'g'?' and I said the acceleration due to gravity. He said so the balloon's accelerating? I said no. But it would be the acceleration that the balloon would have if it was accelerating in freefall. At this point, I was facing my own misconceptions that I had. At this point, I'm self-doubting myself in front of this roomful of physics teachers and everybody taken the first semester workshop. Right there, I saw the strong points in terms of pulling out those misconceptions and having kids talk about their ideas."

Ms. Mango added that she attended another workshop after teaching the course for a year and gained even more than the in the first workshop. *"Then after living through it, I had a lot better questions to ask while I was at the workshop, such as why do we do it this way, so just made much more sense to me than I would've had I gone and then tried to replicate it."*

Increased pedagogical knowledge and pedagogical content knowledge developed in the workshop and in the practitioner's own practice, allows for an easier transition to a new method (Copur-Gencturk, 2015). Increase in application of a new method happens by learning the content used and skills used to transfer the knowledge together. The content and skills become integrated, rather than segregated, allowing quicker recall when needed in practice (Huber & Hutchings, 2004). When the practice also becomes a cultural practice of the school, the transition to the new method is accelerated (Luft & Zhang, 2014). Mr. Birch found this blend of content knowledge and pedagogical knowledge used in the MI workshops helped his classroom instruction indicating, *"I took my first modeling workshop about 15 years ago, I think 2002, and it was an easier transition, because some of the skills for students I was already doing in my classroom. I think I just had to think a little bit more about the big picture and how to make the connections, or how to get the students to make the connections between the content and topics we're doing."* The ability of the building leadership to bring in MI and have teachers across all areas of science embrace the pedagogy has helped the teaching staff to transition to the new methods. Ms. Apricot described the change to MI by saying, *"It only takes one person to get fired up or excited about it and then look at the change that you can bring. And this is not only to their own classroom practice, but it ended up in the entire department."* According to Mr. Pine, *"I've used the phrase 'trying to empower teachers to promote change within the organization',"* when it came to describing his leadership when changing to MI. Ms. Cherry stated, *"I was able to assimilate in [to the department] and then give ideas and they were always very receptive to that. With modeling it's been the same thing."* Mr. Elm did not start as optimistically, but had similar feelings once he tried the change to MI. *"I was somewhat skeptical of some of the people who it already taught modeling, the professor, and how it changes your practice, and how the kids seem more engaged, and how it just seemed like it was the best thing since sliced bread. Then I taught the course one year and really enjoyed it."* It also has helped the leadership to focus additional support on common issues. Mr. Pine described the focus of change for the staff by saying, *"We had the opportunity with the modeling thing to provide an example of our vision of how it could be different."* Ms. Apricot added that MI has helped focus strategies that are branched into other areas of the school. *"We've also added strategies, and modeling is big piece of this,*

to support some of those same strategies and conceptions with things such as cooperative learning," she said.

Professional development is one area that schools often use to invoke change and/or grow the capacity of their staff. Goals of professional development often range, but typically include, increased capacity in one of the following areas: (a) teachers' knowledge, skills, and dispositions; (b) professional community; (c) program coherence; (d) technical resources; and (e) leadership (Newmann, King, & Youngs, 2000). Ms. Apricot identified the development of teachers' skills when asked about the professional development at Orange High School. *"We're really trying to support teachers in that, and our building instructional coaching program route is really focusing on those cooperative learning practices. I think our professional development [PD] focus [student-centered classrooms] has come out of that and what our staff has needed."* Mr. Fir included the balance of leadership, professional community, and increasing teacher aptitude at Silver High School when deciding on methods of professional development. *"When you balance the collective benefit of allowing teachers to work together, acknowledging that when you do that you're taking them out of the classroom, with their students. So, we just made a proposal to transform a big part of our professional development to a coaching model."* Mr. Fir later discussed the idea of differentiating professional development by choosing building goals for professional development that balance these factors and keep staff interested in activities that fit their needs. Balancing staff and building needs may determine whether the program reaches the intended goal. Increasing teachers' knowledge and skills, along with program coherence, and building up of the professional community, were all accomplished with professional development training in transitioning teachers at each school from traditional instruction to MI.

Two-week MI summer workshops were the main source of this professional development, which allowed teachers to learn both the content that would be taught in the MI curriculum units, as well as experience how the role of the teacher changes from instructor to facilitator. Teachers responded very well to the amount of professional development they received. Ms. Pear discussed how her school would find professional development for almost any idea that teachers thought would be beneficial. *"For professional development, I think it's out there, that if we find something we think would be beneficial, we can put in for it,"* stated Mr. Pear. Ms. Cherry discussed professional development options, *"Professional development was also something I walked into here that was amazing to me."* Mr. Hickory added, *"For professional development, we offer a ton; it's really generous."* Workshops take teachers through the first units of their respective course work, with the teachers acting as students who perform labs, solve problems, and take a few assessments. Teachers also participate in whiteboard presentations and all other aspects that a student would encounter in a typical MI classroom. Having the teacher perform these lessons allows them to identify misconceptions while working on pacing when designing lessons for their classroom. Proper pacing and identification of potential problems are areas where teachers can struggle when implementing new curriculum, so the workshop helps to alleviate potential future stressors (Milkova, 2016).

The workshop facilitator models the role of the teacher by asking questions and modeling the new roles teachers may assume in an MI classroom, providing teachers with examples of how the classroom should appear. As a result, teachers increase their knowledge base to better help students when faced with similar situations in their own classroom (Adadan & Oner, 2014). During this time, teachers not only see the change in the role of teacher, but also that of their interactions with students and questioning. Teachers also have the opportunity to ask why the facilitator is doing or not doing specific things, such as asking probing questions or allowing students time to work independently during laboratory investigations, to better familiarize themselves with the pedagogical shift.

Many teachers also attend multiple MI workshops; some choose different subjects, but some attend the same workshop to better understand the philosophy involved in teaching MI. Workshop facilitators who were interviewed mentioned how they learn something new every year, allowing them to better their practice during the following school year. Mr. Aspen responded, *"I've been lucky enough to lead workshops the past couple summers as well, so I'll be doing E end M [Electricity and Magnetism]. I think they're great; I learn more than anybody every time I participate in one."* Mr. Birch stated that his learning from other teachers attending the workshops goes beyond content knowledge by saying, *"I think what I lack a little bit was allowing kids to see the connections between each unit."* He stated that the ability to see connections between units is something that other teachers point out, which he can bring back into his own classroom. Mr. Oak describes the process of the workshops as a great learning tool, but something that is only the beginning of the process. *"If it was described in one word, I might say not sufficient. You probably need at least two workshops and then years of experience, since you learned so much in those first few years of doing it. Both in terms of what to do and what not to do,"* according to Mr. Oak.

Outside the two-week professional development workshop during the summer, teachers also experienced continued professional development in the form of collaboration. Collaboration among faculty members was done both formally, in times designated by school leadership, and informally through daily conversations. Formal collaboration came in the form of Professional Learning Community (PLC) time, where science staff worked in groups to meet various objectives. Even though PLC effectiveness has been debated, it has been proven to be most effective when it involves organizational practices, the substantive details of PLC activity meetings, the nature of conversations in PLC activities, and the development of community among PLC teams (Graham, 2007). Participation from the whole science department helps to focus PLC objectives with organizational goals. Mr. Pine noted that having PLC goals align with school goals has increased productivity and teacher ownership. *"They see it is a worthy goal. We have tried to have that [argumentation based on evidence] as a goal in all of our PLC's across the building this year. I think it's been stronger in science than in some other areas,"* explained Mr. Pine. Having all teachers using the same approach helps to build community and streamline conversations for maximum effectiveness during designated PLC time. Ms. Plum stated, *"We have a really good PLC"* when discussing the content shared and discussions. *"There's no problem sharing. We have a PLC team and there's a lot of sharing there,"* responded Ms. Apple. Mr. Aspen said, *"Our small group for physics, our physics PLC,*

we're physics team we are constantly talking." Mr. Birch added, *"PLC's have been a big help in providing us the time to do that [collaborate]. I think, overall, teachers have been very good with sharing."* Mr. Willow described the sharing of ideas during PLC time as *"pretty awesome."* He then went on to say PLC time was *"probably the best thing about coming here."* Mr. Elm described collaboration time at Orange High School*, "We have TCT's, where we just meet as the department, which I found efficient and productive."* Teachers at both schools favored sharing and agreed about the effectiveness of the PLC time that was given by building leadership.

Informal collaboration took place at various times during the day, and helped teachers to obtain immediate feedback or guide each other towards effective practices. This collaboration ranged from conversations held in offices and in hallways, and even included peer observations with follow up, where the teachers would meet again to discuss what they witnessed. Mr. Willow described the sharing and time spent with other teachers, *"Here, there was a year where I shared a room with nine other teachers. So just the amount of knowledge of the people and their willingness to share or just talk to you. There's a lot of brilliant minds just in the building who will share or just let you watch."* Statements such as these were common when discussing the sharing of ideas and materials that seemed common practice amongst the teaching staff using MI. Collaboration that is specific to the classroom decisions being made by faculty members and is reflective in nature expands on the professional development received by the teaching staff. Reflection and collaboration on specific practices allows teachers to transition to MI and improve student learning at a faster rate (Dearman & Alber, 2005). Increased collaboration amongst staff also increases retention and student achievement (Devlin-Scherer & Sardone, 2013). Allowing staff to develop, as well as the ability to retain staff are important factors for schools*. "I think the number one role of the department chair is recruitment and development of teachers,"* according to Mr. Maple. He also went on to discuss the specific circumstances at Orange High School that make this difficult*. "In our district, we're in the lower end of the pay scales in the county, so we have to go recruit teachers."* Mr. Maple later described how collaboration and building helpful relationships aid in retention by making the workplace more enjoyable*. "The people up here, and for the most part, the people in the building really enjoy it, so that makes it a really nice place to come."*

Collaboration has also made the whole science department transitioning to MI easier, because with it came a new pedagogy and curriculum, which provided a common platform for all teachers in the department. *"We have a common language that we speak,"* said Mr. Oak. *"This lets us throw ideas back and forth about our approach to teaching"*; this is something that Mr. Oak felt MI improved in the way in which the department collaborated. Common language and beliefs are key factors in accelerating the collaboration amongst groups of individuals (Miller & Katz, 2014). These factors may be key, since they build a common platform for relationships and future conversations. Ms. Mango added*, "We collaborate all the time; we have a lot of common ground, and we know that we always have a lot of work to do."* The MI pedagogy had teachers focusing on student-centered classrooms, which was something the new science standards required and the building administration wanted to see. Ms. Apricot described the concept of students and teachers working and learning together as part of the school culture with much of it

being attributed to modeling, *"and modeling is big piece of this."* She then described how training was accomplished, and how teacher feedback and collaboration was used to better discuss how the school can work to support the staff in helping with motivation, engagement, and student ownership.

All teachers working towards MI provided opportunities to learn techniques together, and allowed leadership the opportunity to shape the role of the teacher in the manner which they saw best fit. Mr. Pine described the process used and the growth of his staff during MI training. *"We then took the whole team to modeling training and got the whole team on the same page,"* he said. *"Over a period of a couple years, most of the members of that team also did a second level of the modeling training, and it ended up being a great team."* Teachers also developed a strong sense of community, with all teachers learning together and sharing their experiences for the benefit of all parties. Teachers were encouraged to collaborate and visit each other's classroom to gain a better understanding of how their new practice would appear. This experience of collaboration and classroom observation was mentioned by Mr. Pine, Mr. Maple, Mr. Oak, Mr. Willow, Ms. Cherry, Ms. Pear, Mr. Aspen, and Ms. Plum, showing that both teachers and the leadership (department chairperson) value collaboration and sharing in conjunction with MI. Mr. Maple stated, *"His [Mr. Oak's] colleagues began to walk by his classroom and want to know what's going on in there; they started to ask questions as they were fascinated."* Ms. Plum spoke about classroom observations being a two-way learning tool. *"Mr. Maple is either in my classroom looking at how it's going or what it is that we're doing,"* she said. *"I'm also in somebody else's class at least once a week, so it's a give-and-take."* She then added, *"I also like to get other people's classrooms [for observation] to learn from them and see how they do things."* Mr. Birch spoke of the formal classroom observations that teachers can sign up for at Orange High School, *"teachers can sign up to come into another teacher's classroom,"* which the school used as a form of professional development. *"He [Mr. Pine] was willing to observe them [Mr. Hickory's lessons], so I got help, and he helped to connect me to people who could help with certain things,"* said Mr. Hickory. This was how he described how observations have helped increase collaboration and development of staff. Mr. Willow summed up the culture of observing and sharing by saying, *"It's not weird if you're just in someone's class or if you share a room and you just watch him for little while. I've done it tons of times; I've watched a couple of other chemistry teachers sometimes, because they have a different knowledge and skill sets that I do. So that's probably been the best collaboration."* Common materials and language brought to the school with the MI framework also allowed for collaboration to be focused on specific targets. Specific targets were made available by MI including a curriculum, which allowed for teachers to use the same (or very similar) lesson plans.

Transformational leadership takes advantage of collaborative innovation and motivation of all members, with a focus on the shared goals of the organization and development of the capacity of the individuals within the organization (Bass, 1990). Both schools made organizational shifts from traditional instruction to student-centered classrooms using MI. During this process, the leadership at both schools encouraged staff to grow and develop materials to make the curriculum their own, which is one of the four

I's — individualized consideration. School leadership provided support, time for reflection and collaboration, and professional development to increase and continually improve the capacity of the teachers in the science department (Dearman & Alber, 2005). Idealized influence was also present, and was heard with statements of building trust and respect. Ms. Apricot stated, *"This is the piece that I love about relationship and trust and risk-taking and supporting. It's a perfect example of how this works in our school."* Support was mentioned by all levels, from administration to teaching staff, with most individuals mentioning the way in which it helped the school, staff, and students. Ms. Apricot, an administrator, described her role as focusing on*, "working with students and teachers on best practices in the classroom." "I also work with teachers on how to support them bringing those things to fruition in the classroom with students."* She continued. Reciprocal feelings were mentioned by the teaching staff. Mr. Aspen described his building leadership as being *"very supportive of what we do; they're definitely allies in everything that were trying to accomplish up here."* Inspirational motivation was also part of the support from leadership, pushing staff members to develop themselves and take advantage of learning opportunities. When speaking of professional development, Mr. Aspen stated*, "It's encouraged too; I'm taking biology this summer because why not. I'm never going to teach biology, but it's a professional development opportunity available to us."*

Leadership also attempted to improve teacher capacity by the use of professional development and collaboration. Pushing staff to learn new skills and techniques provides intellectual stimulation, which is also one of the four I's of transformational leadership. Teacher growth is one factor of transformational leadership that was apparent from the data. Improved teacher capacity provides teachers with the ability to become more flexible in their instruction, which leads to improved achievement by students (Desimone, Porter, Garet, Yoon, & Birman, 2002). The leadership at both schools in this study were focused on improving the student experience in science by increasing the ability of the science department staff. Use of professional development, in conjunction with time and themes for collaboration, produced departments where methodology and instruction were able to transform in a few years.

The leadership at these schools seemed to be there for the teaching staff and push them towards improving themselves for the betterment of the organization. In addition, other types of leadership were also present. Mr. Maple stated, ***"nobody is going to work in this department unless they have been to a MI workshop."*** This exchange of a job for attending a workshop is in line with the rewards and consequences belief of transactional leadership (Bass, 1990). Transactional leadership was present, but not overwhelmingly used. Doing tasks as a favor for one's supervisor can be seen as practice in most workplaces. Actions that developed teaching, instructional, pedagogical ability and well-being were present too. Again, the overall organizational development was focused on the instruction of students, not solely the development of teachers.

Implications for Administration

From these themes, implications for school administrators and other school leaders have emerged for the successful change in teaching methods, particularly MI. Some recommendations may be practical for making other changes in a school setting as well.

School leaders should identify and have examples of the changes they would like to have in their building/department. Once that vision is identified, faculty must be educated on the new techniques with proper training. This training must provide an overview of what the change is, why it is necessary, and models of how it will appear. Ongoing support and collaboration will also be required to ensure the change continues to meet the needs of the students and the initial goals of the change. Support from leadership will allow the staff to have the resources required for the change, but it should also foster a relationship where the teaching staff feels comfortable discussing problems open and honestly with their leadership. Two-way dialogue and collaboration among all stakeholders involved regarading the change process will provide channels for the staff to not only meet the objectives of the change, but also for the organization to adapt if the change is not meeting their intended goals. This continued collaboration and professional development will allow staff to become comfortable with the new system in a supportive environment.

School leaders should build trust with their teaching staff. Interview data was filled with teachers talking about how much the school leadership supported them in their practice. Oftentimes, teachers referred to the support as the administration treating them as professional and not micromanaging every detail. Development of trust takes time, and as administrators in this study discussed, building relationships with members of their teaching staff is a priority.

Listening to teacher input is another area where school leadership can help to create a smooth transition to a new directive. In this transition to MI, teachers' needs were met through dialogue with leadership and by support. Creating an environment where teachers feel comfortable approaching leadership when problems arise allows school leaders to take a more active role in the transition.

Providing the staff with time to collaborate during this change was another area where leadership helped to create an environment that supported change. When facing a change in routine, individuals often feel frustrated, as they face new problems and may not have the skills to bring about the proper solution. At both schools, time was allocated to the teaching staff to discuss what was working and/or not working. This time was also free of judgement, and leadership was only involved to offer support, not evaluate, which created an open environment where true feelings of the change could be expressed.

Freedom to fail is another aspect where the administration allowed teachers to make mistakes, using reflection as a way to improve capacity in a non-threatening way. This process involved using observation and collaboration as tools to allow staff to share ideas and experiences. Using these strategies for reflection and growth, rather than a time to see teachers making mistakes that would appear on their professional evaluations. *"In one of my observations, when Mr. Pine came in, we probably had the greatest discussion yet,"* described Mr. Elm. Ms. Apricot described her role, as an administrator, in this process. *"We have high risk-taking conversations and we're changing things up, and talk about*

ways to teach, what to do with our students, and I'm in their classrooms," she said. Ms. Mango added, *"Mr. Pine is really supportive with new ideas and also helps us a lot when he wants us to try something new."* Mr. Oak described the feeling of support during the transition to MI. *"Everywhere along the way when we've come to them with parts of implementing modeling, they [building leadership] said, 'yeah, we'll do it.' Again it's in the building, but in the district as well,"* he said. The use of this freedom to try new things in a manner where teachers feel comfortable taking calculated risks is an environment that was fostered at each school. Beyond taking risks, teaching staff at each school felt comfortable going to other teachers and building leadership with deficiencies, with the intention that they would receive help rather than criticism.

Areas for Further Research

This study involved the change in instruction from traditionally taught classes to MI at two high school science departments. Evaluation of other schools could provide more data in order to determine if the change to MI has always been successful and/or if the change process was also similar.

MI also offers middle school materials, so examining a change in instruction at lower grade levels needs to be researched.

Similar studies could also be completed to evaluate the change in other instructional methods. Changes in instructional methods could mean changes in other subject matter or changes to other science methods. Future research could help identify if the same themes help foster changes of any kind within the school setting.

Conclusion

Science education has long struggled with the balance between content knowledge and the practical application of skills to investigate phenomena. Modeling Instruction (MI) is a program that balances those goals by providing students an opportunity to investigate and later identify the scientific principles of what just occurred. Expansion of the science standards to NGSS has shifted the focus of science education, but organizational changes can be difficult to bring to fruition. The change to MI can be difficult for school staff, since it removes teachers from the stage in delivering information and placing them as facilitators asking students to expand their explanations of what they observed. The teaching staff at each school in this study have effectively transitioned to a technique that places students at the center of the learning process, in addition to moving their science departments to methods that are aligned with NGSS, which will help students in their future endeavors.

Transitioning the teaching staff to a practice where the roles they learned in preparation programs and practiced in their own professional duties differ took planning by school leadership. Processes and supports were put in place, allowing the teaching staff to make this transition in a comfortable and positive manner. Leadership support, professional development, time for collaboration, common beliefs, and transformational leadership were all factors that were put in place, which allowed MI to move from being a change to part of the school routine. These factors provided teachers with models of how the change would appear, introduced them to the methods and rationale of the change, and gave them room to grow into the new routine with the help and support of their peers and

leadership. Changes appear to be a constant in education, but **this transition shows that with proper planning, change can go from something that divides and creates tension, to something that unifies and embraces individuals for their new beginnings.**

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Appendix C: School Leadership Interview Protocol

1. How would you describe your style of leadership?
2. What are you doing that attributes to your school being so successful?
3. What is the focus at your school?
4. What would you say the overall expectations are for the students in the building?
5. Describe the collaboration at your school.
6. Describe the school environment.
7. What is the family and community involvement like here at your school?
8. What are the professional development expectations?
9. How was Modeling Instruction introduced to you or your school?
10. How did you begin the implementation of Modeling Instruction classes?
11. How did administration influence the decision to begin using Modeling Instruction?
12. What professional development was provided or made available for the transition to Modeling Instruction?
13. Was the community involved in the decision to begin using Modeling Instruction?
14. How did the community react to the implementation of Modeling Instruction?
15. What is or has been your direct involvement with Modeling Instruction?

Appendix D: Faculty/Staff Interview Protocol

1. How would you describe your administration's style of leadership?
2. How often is a member of the building leadership in your classroom?
3. What are you doing that attributes to your school being so successful?
4. What is the focus at your school?
5. What would you say the overall expectations are for the students in the building?
6. Describe the collaboration at your school.
7. Describe the school environment.
8. What is the family and community involvement like here at your school?
9. What are the professional development expectations?
10. How was Modeling Instruction introduced to you or your school?
11. What does your leadership do to support your teaching?
12. How did you begin the implementation of Modeling Instruction classes?
13. Describe the process that teachers went through to be trained to teach using the Modeling Instruction pedagogy.
14. How did administration influence the decision to begin using Modeling Instruction?
15. How did staff members influence the decision to begin using Modeling Instruction?
16. What professional develop was provided or made available for the transition to Modeling Instruction?
17. Was the community involved in the decision to begin using Modeling Instruction?
18. How did the community react to the implementation of Modeling Instruction?
19. What is or has been your direct involvement with Modeling Instruction?

Appendix E: Leadership Checklist

Leadership Characteristic	Supporting Data
Gives up responsibilities and avoids making decisions.	
Various kinds of rewards in exchange for mutually agreed-upon goal accomplishments.	
Watches for deviations from organizational rules and standards, and takes corrective action.	
Intervenes only if standards are not met.	
Arouses followers' emotional attachment to the leader and identification with him or her.	
Engages followers in recognizing and confronting challenges, and in viewing challenges from new perspectives.	
Provides support, encouragement, and coaching.	
Communicates an appealing vision, using symbols to focus efforts, andmodeling appropriate behaviors.	
Listens intently to others and helps reinforce the will of others by using this skill.	

Appendix E (cont.)

Leadership Checklist

Leadership Characteristic	Supporting Data
Seeks to identify with followers and often goes out of the way to help others feel accepted and valued.	
Assists others in overcoming emotional difficulties.	
Aware of his or her role and how it works in sync with the organization and others in it.	
Often relies on persuasion rather than authoritative positional authority when making decisions and leading the organization.	
Takes a holistic approach to the entirety of a situation and not just the elemental steps of a given moment.	
Relies on a certain degree of intuition based on experiences from the past and elements of the present.	
Committed to serving the needs of others to yield organizational progress and achieve goals on behalf of the organization.	
Exhibits an emphasis on ensuring that followers realize their worth and overall value in the organization and as individuals.	
Sets examples for others so that, in turn, others become servant leaders.	

Appendix F: School-Site Observation Checklist

Vision	
The school has a clear sense of purpose.	
The staff has a clear understanding of what the school is trying to achieve.	
The staff shares a common understanding of what the school wants to achieve.	
All staff are committed to achieving the school's goal.	
The staff keeps the school's goals in mind when making important decisions.	
The school's primary emphasis is on improving student learning.	

Appendix F (cont.)

Standards/Expectations	
All students are expected to achieve high standards.	
Teachers do whatever it takes to help all students meet high academic standards.	
Teachers believe all students can learn complex concepts.	
All students are consistently challenged by a rigorous curriculum.	
Teachers use effective strategies to help low-performing students meet high academic standards.	

Appendix F (cont.)

Leadership	
Many staff provide leadership in some way.	
Leaders advocate for effective instruction for all students.	
People in leadership roles act with integrity.	
School administrators consider various viewpoints when making decisions.	
Leaders hold staff accountable for improving student learning.	
Staff feel like the school leadership cares about them.	

Collaboration/Communications	
The school uses a system to obtain a variety of perspectives when making decisions.	
Teachers discuss teaching issues on a regular basis.	
Staff members work together to solve problems related to school issues.	
The staff works in teams across grade levels to help increase student learning.	
Staff routinely work together to plan what will be taught.	
Teachers have frequent communication with the families of their students.	
Staff members trust one another.	

Appendix F (cont.)

Alignment to Standards	
The school's curriculum is aligned with state standards.	
Instructional staff have a good understanding of the state standards in the areas they teach.	
Instructional materials aligned with the state standards are available to staff.	
Instruction builds on what students already know.	
Schoolwork is meaningful to students.	
Teachers use a variety of approaches and activities to help students learn.	
Classroom activities are intellectually stimulating.	

Teachers know the research basis for the instructional strategies being used.	
The staff uses assessment results to plan instructional activities.	

Appendix F (cont.)

Monitoring of Teaching and Learning	
Students receive regular feedback about what they need to do to improve.	
Students receive extra help when they need it.	
Teachers modify their instructional practices based on classroom assessment information.	
Teachers receive regular feedback on how they are doing.	
Teaching and learning are the focus of staff observations and evaluations.	
Teachers provide feedback to each other to help improve instructional practices.	
High-quality work is expected of all the adults who work at the school.	

Professional Development	
Assessment results are used to determine professional learning activities.	
Staff members get help in areas they need to improve.	
Professional development activities are consistent with school goals.	
Teachers have enough opportunities to grow professionally.	
Different staff members periodically lead professional development activities for other staff.	
Instructional staff view themselves as learners, as well as teachers.	

Appendix F (cont.)

Learning Environment	
Students feel safe on school property during school hours.	
The school environment is conducive to learning.	
Teachers show they care about all of their students.	
The staff respects the cultural heritage of students.	
Students respect those who are different from them.	
Instruction is adjusted to meet individual student needs.	
Student discipline problems are managed well.	
The staff feels free to express their ideas and opinions with one another.	

Family and Community Involvement	
The staff believes students learn more through effective family support.	
The school works with many community organizations to support its students.	
The school makes a special effort to contact the families of students who are struggling academically.	
Teachers have frequent contact with students' parents.	
The school provides ample information to families about how to help students succeed in school.	
Many parents are involved as volunteers at the school.	