Perceptions of Science, Mathematics, and Technology Education Teachers on Implementing an Interdisciplinary Curriculum at Blaine Senior High

by

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ABSTRACT

This research examined perceptions of mathematics, science, and technology education teachers regarding the interdisciplinary curriculum approach.

Information gathered in the literature review was used to develop a survey instrument that measured teacher perceptions. Most of the questions used a five point Likert scale measuring system. Topics included working with teachers in other curricular areas, the definition of interdisciplinary curricula, and willingness to implement change in the classroom.

Results suggest the interdisciplinary approach suffers from an identity crisis. The subject population was greatly divided among three possible descriptions. However, the subject population expressed strong agreement on recommended interdisciplinary elements, such as instructed laboratory activities and problem solving. Teachers expressed willingness to

The results of the study suggest interdisciplinary education reforms are suffering from an identity crisis. When given three possible choices, the subject population was greatly divided over which description best captured the essence of an interdisciplinary approach. Despite differing perspectives on how to describe an interdisciplinary approach, the subject population expressed strong agreement on specific elements that should be included in the approach, such as instructed laboratory activities and an emphasis on problem solving. Teachers expressed a willingness to cooperate with teachers from other curricular areas, and to experiment with new approaches in their classrooms. Teachers also shared insights about barriers to implementing new approaches, including lack of resources and the need to focus on required achievement initiatives such as proficiency testing and graduation standards.

As a result of the study, five recommendations were made. First, a financial analysis should be conducted to estimate whether implementing an interdisciplinary curriculum of mathematics, science, and technology education at Blaine Senior High would be economically feasible. Second, it was further recommended that staff development funds be utilized to educate teachers and administrators about the key concepts that underpin successful interdisciplinary approaches. Third, solicit teacher perceptions after allowing them to implement at least one interdisciplinary unit that was developed cooperatively. Fourth, develop and implement an interdisciplinary unit for some students, then compare student performance on identical assessments of the material presented. Finally, it was recommended that Minnesota graduation requirements be enhanced to promote compatibility with interdisciplinary curricula.

Three areas for further study were also identified. First, it would be useful to conduct a larger study to include mathematics, science, and technology education teachers throughout the Anoka-Hennepin District. Second, it would also be useful to know what perceptions exist among school administrators regarding the implementation of an interdisciplinary curriculum. Finally, parents and students might have valuable insights on whether or not an interdisciplinary curriculum would be valued. These individuals would not be expected to be familiar with the advantages and disadvantages of various curriculum approaches, and would need an explanation of the differences between traditional curricula and interdisciplinary approaches.

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Chapter I: Introduction

The signs of technological change are all around us. Cell phones are now commonplace, hybrid electric vehicles are mass produced, and we use the Internet to exchange information with people around the world instantly and with a level of convenience unimaginable just a few years ago. M. James Bensen emphasized the transformational impact technology has had on our society when he stated, "The power and force of technology today is self-evident. It is fueling rapid change and global competition as never before" (Bensen, 1995, p. 261). Consequently, we live in a world where advances in technology and science have altered nearly every aspect of daily life.

To see that this will continue, consider for a moment how much we know. The human knowledge base is expanding at a fearsome pace. Over ten thousand new scientific articles are published *daily*. That means the knowledge base is currently doubling every seven years. When our grandparents were our age, the doubling spanned one human lifetime. What is more startling is that the rate of increase is increasing (Bensen, 1995; Oblinger & Rush, 1997). In fact, there is so much information that science and technology educators are increasingly overwhelmed. Class time is a limited resource, and there is simply not enough time to teach everything. Teachers are struggling as they attempt to prioritize class time and determine what topics are most essential, how much depth and detail to add, and what methods will be most effective.

Research seems to indicate that American students are not keeping pace with these rapid technological changes. *A Nation at Risk: The Imperative for Educational Reform,* a 1983 study carried out by the National Commission on Excellence in Education, and the 1991 report entitled *The High Stakes of High School Science*, a study carried out by The National Center for

Improving Science Education, addressed this and many others issues which indicated that America's education system was no longer superior in the global community. The studies indicated that American students avoid courses related to or involving science, did poorly in courses they were required to take, and were unable to relate science and technology to everyday life. In international comparisons of student achievement, American students were never first or second, and were last seven times. The studies noted a national illiteracy rate of 13% among 17 year old students, with rates as high as 40% among minorities, and evidence that gifted and talented students were also exhibiting substandard performance (NCEE, 1983; NCISE 1991).

Many educational reforms have attempted to address the findings of *A Nation at Risk* and *The High Stakes of High School Science.* These changes in education have typically occurred within individual disciplines of study, rather than using a unified approach (Rossiter, 2002). Wicklein and Schell (1995, p. 59) described the consequences of using this approach to create better curriculum as “a segregated approach to instructional topics which does not adequately address the reassemblage of topics into a coherent body of knowledge to be used by students."

Other experts have attempted to alleviate the problem through the development and implementation of educational standards. According to Doolan and Honigsfeld (2000), the stunning inadequacies identified in *A Nation at Risk* have been largely responsible for today's standards-based education reform movement. These standards initiatives represented an effort to help educators by establishing common understandings regarding what well prepared students should know in various disciplines. In developing these common understandings, the standards authors hoped to at least determine the scope and sequence, answering the questions of what topics are most essential and how much depth and detail to add.

The *Goals 2000: Educate America Act* was signed into law by President Clinton in 1994. *Goals 2000* supported standards-based initiatives in two key areas. It supported state efforts to develop clear and rigorous standards for what American students should know and be able to do, and it supported comprehensive state and district-wide planning and implementation of school improvement efforts focused on improving student achievement to meet those standards. As a result, standards development is underway or has been completed in 49 states for the core academic areas of math, science, English, and social studies (Marzano, 1996; American Federation of Teachers, 1999).

Examples are numerous. The National Research Council, through the National Committee on Science Education Standards and Assessment, has developed goals and guidelines for improving K-12 science education with the *National Science Education Standards* (NRC, 1996). The National Council of Teachers of Mathematics published the *Principles and Standards for School Mathematics* for pre-kindergarten through high school mathematics curriculum (NCTM, 2000). The International Technology Education Association has led the way with the *Standards for Technological Literacy* (ITEA, 2000).

One of the most important changes in these recent standards development efforts, when compared with past education reform initiatives, was the effort to improve student connections to real-world applications and to include multi-disciplinary perspectives. These include mathematics, science, and technology standards that emphasize connections to other disciplines, establish real-world applications, and incorporate personal, social, and political perspectives (NRC, 1996; ITEA 2000; NCTM, 2000). This helps students understand the interplay between different curricular areas, and it helps them recognize important connections between education and the world beyond their school campus.

These new efforts come at a critical time. The decline in the performance of American students in the international community is not just alarming to educators. Voices are being raised expressing concern that while our culture becomes increasingly technologically and scientifically oriented, Americans are becoming less technologically and scientifically literate. We are losing the ability to understand the technology and science that underpin the high standard of living that many Americans enjoy, according to Cheek (1992). Science, math, and technology are a practical necessity for understanding the natural environment and contemporary culture, especially when science and technology permeate U.S. life (NCISE, 1991). The NCISE further emphasized the need for this type of education for maintaining a strong democracy, strengthening the economy, and promoting scientific achievement. All of these demand a "scientifically literate citizenry" (NCISE, 1991, p. 1). Research by the National Science Foundation seems to support this notion, citing shortages of qualified employees. Their report, *Science and Engineering Indicators – 2004,* stated that there were over 1,300,000 engineering or engineering technology jobs available in the U.S. without trained people to fill them (NSF, 2004).

Harold C. Livesay expressed concerns about education within a national security context, stating that "Maintenance of national well-being depends, at least in part, on a nation's ability to generate and adopt the technology necessary to maintain economic competitiveness and, in the case of the United States, a credible force with which to defend ourselves and our allies." (cited in Squires, 1986, p. xiii). Bensen expressed similar thinking when he stated, "The study of technology is imperative for the well-being of our nation and the common good of our people." (Bensen, 1995, p. 261). Some have taken a more alarmist position, suggesting that chronic technological illiteracy will eventually bring about the downfall of Western civilization as we know it (Spiegel-Rosing & de Solla Price, 1977; Cheek, 1992).

Clearly then, it is critical that the leaders of tomorrow fully comprehend the relationship of scientific and technological advancements with societal wants and needs. For better or worse, this relationship has become one of the cornerstones of our participatory democracy, and it increasingly requires a knowledgeable, thinking, technologically literate populace.

Many experts feel that technology education is uniquely suited to create these knowledgeable, technologically literate thinkers. According to Zuga, technology education prepares students to function in a technological society by providing application and immediate relevance to principles in math, science, and other subject areas. These courses focus on the development and application of technology, and they develop students who are self-learners and problem solvers, as well as self-reliant and productive members of society (Zuga, 1987). M. James Bensen supported Zuga's contention in his rationale for technology education, arguing that students need technology courses to prepare them for roles as citizens and consumers in a technological culture. In order to make intelligent choices, he argued, they must be technologically literate (Bensen, 1988). Furthermore, technology education combines knowledge of mathematics and science with the study of human endeavors. It also integrates ideas about creating and using tools, techniques, resources, and systems to manage man-made and natural environments for the purpose of extending human potential – as well as the relationship of these to individuals, society, and the civilization process (Sterry & Wright, 1987). However, the most compelling reason to utilize technology education to meet this need is that the defining feature of technology education's curriculum is its use and reliance on hands-on, experiential learning (Pearson & Young, 2002; Snyder, 2004).

A consensus seems to be forming with regard to how students should be taught about science, math, technology, and society. The *National Science Education Standards*, the

Principles and Standards for School Mathematics, and the *Standards for Technological Literacy* are manifestations of this. Acting on the shared recommendations of these standards initiatives, many schools across the United States have begun to present a multi-disciplinary approach. This form of education is by definition multi-disciplinary, as it connects science, technology, engineering, and math (commonly referred to as STEM).

Several studies back the benefits of incorporating a multi-disciplinary curriculum. Research in the area of education, as well as in cognitive science, suggests that curriculum variations featuring an inter-disciplinary curriculum are likely to promote more learning (Loepp, 1999). Wicklein and Schell (1995) performed four separate case studies using a multi-disciplinary approach to mathematics, science, and technology education. The findings from this case study were not limited to student improvements. Faculty agreed that a multi-disciplinary approach created a learning atmosphere that provided students with a unique opportunity to learn in a much broader context.

This has been done predominantly through the adoption of an engineering-based curriculum to replace or augment the technology education curriculum (Lewis, 2004). The engineering program makes use of what students learn in every class, combines it, applies it, and provides the opportunity to solve real world problems and case studies. This closely matches the job description of what engineers do, since “engineers apply the theories and principles of science and mathematics to solve technical problems. Frequently the engineer's work makes the connection between scientific discovery and real-world application” (Deal, 1994, p. 15).

The Project Lead The Way (PLTW) model is arguably the most prominent version of high school engineering curriculum being implemented today. PLTW is now offered in every state and the District of Columbia, with a total exceeding 3,000 schools. More than 250,000 middle school and high school students are enrolled in PLTW classes (PLTW, 2008). The PLTW approach has been tremendously successful, as have other multi-disciplinary approaches that integrate science, technology, engineering, and math (STEM) to teach students advanced concepts about the technological world around them. Students and parents have described the program as valuable and challenging, and industrial advisory board members have praised the program during visits. PLTW and similar programs should increase the pool of students ready, willing, and able to enter engineering and technology career fields after high school, either directly or via post-secondary educational programs (Ried & Feldhaus, 2007).

Blaine High School in Blaine, Minnesota has implemented the Project Lead The Way model to integrate math, science, and technology education for a fraction of its students. This was accomplished by offering interested students an interdisciplinary curriculum of required math and science courses with elective engineering courses. Since the program is elective in nature, it will influence around ten percent of the students in each grade level, as currently implemented. This will only occur at Blaine Senior High, because the other five high schools in the district do not offer any PLTW classes. Furthermore, none of the other high schools use an interdisciplinary approach to mathematics, science, and technology education as part of the required curriculum for all students.

This is the case more often than not. Throughout the 1990's, curriculum integration and its application has been a consistent and important theme in education reform strategies, yet very few schools have adopted this reform in practice (Wisconsin Department of Public Instruction, 1999). This has happened despite praise from parents and students who describe the approach as valuable and challenging (Ried & Feldhaus, 2007); despite recommendations from numerous experts in the field and standards initiatives in science, math, and technology that call for implementation of a multi-disciplinary approach; and despite research that shows integrating the math, science, and technology education curriculum helps students across a wide range of academic achievement (Wicklein & Schell, 1995; Bailey, 1997). Considering the widespread praise and research evidence that interdisciplinary curricula are successful, it seems curious that there is so little actual application.

Statement of the Problem

Mathematics, science, and technology education curricula share the common goal of preparing students for life in a technological society. Research that shows integrating math, science, and technology education curriculum helps students across a wide range of academic achievement (Wicklein & Schell, 1995; Bailey, 1997). Parents and students described various interdisciplinary approaches, such as Project lead The Way, as valuable and challenging (Ried & Feldhaus, 2007). Numerous experts in education and the authors of standards initiatives in science, math, and technology advocate a multi-disciplinary approach.

At this time there is no data to determine if the mathematics, science, and technology teachers would support or oppose a curriculum reform with the purpose of implementing an interdisciplinary curriculum for all students at Blaine Senior High.

Purpose of the Study

The purpose of this research was to determine perceptions of mathematics, science, and technology education teachers regarding various aspects of the interdisciplinary curriculum approach. The research data was collected using a printed survey, circulated to all teachers in mathematics, science, and technology education at Blaine Senior High during the 2008/2009 school year.

Research Questions

This study should answer the following questions about the perceptions of mathematics, science, and technology teachers at Blaine Senior High:

1) What is the main concept that defines an interdisciplinary curriculum?

2) What elements should be included in an interdisciplinary curriculum?

3) Do current curricula contain elements, either planned or unplanned, which are consistent with an interdisciplinary approach?

4) Would an interdisciplinary curriculum of mathematics, science, and technology enhance student learning?

5) Would an interdisciplinary curriculum of mathematics, science, and technology improve upon the current curricula for mathematics, science, and technology education?

6) How comfortable are teachers with implementing curriculum change in their classrooms?

7) Does a lack of time, money, or other resources make it difficult to implement an interdisciplinary curriculum?

8) Is there a difference in attitude between the mathematics, science, and technology education teachers toward the implementation of an interdisciplinary curriculum?

9) Do teacher perceptions of other curricular areas make them more or less likely to cooperate in an interdisciplinary curriculum?

10) Does required curriculum such as graduation standards make it difficult to implement an interdisciplinary curriculum?

11) Would an interdisciplinary curriculum support the learning goals of our high school?

12) Do current curricula provide a holistic learning experience?

Significance of the Study

The following information will be derived from this study:

1) The study will identify the level of interest of mathematics, science, and technology education teachers at Blaine High School for the implementation of an interdisciplinary curriculum. Teachers of each discipline will be able to convey their impressions regarding an interdisciplinary STEM curriculum of science, technology education, and mathematics. The findings will be used as part of a feasibility study for the implementation of an interdisciplinary curriculum of science, technology education, and mathematics for all students at Blaine Senior High, and potentially in all of District 11.

2) The study will help stakeholders gain a common understanding of what an interdisciplinary curriculum might look like if it was implemented at Blaine Senior High. It will explain the important differences between an interdisciplinary curriculum and the traditional curriculum that the large majority of students currently experience. This information will be used as part of a feasibility study for the implementation of an interdisciplinary curriculum of science, technology education, and mathematics for all students at Blaine Senior High, and potentially in all of District 11.

3) It will consolidate research findings, professional recommendations, and other useful information to help illustrate how an interdisciplinary approach could provide a more holistic and effective educational experience than the traditional curricula being used currently. This information will also be used as part of a feasibility study for the implementation of an interdisciplinary curriculum of science, technology education, and mathematics for all students at Blaine Senior High, and potentially in all of District 11.

Limitations of the Study

Potential limitations to consider when reviewing this study include:

1) The sampling of teachers was limited to mathematics, science, and technology teachers at Blaine Senior High. The small sample size might limit the applicability of the results beyond Blaine Senior High.

2) The survey was developed by the researcher and thus lacks documented validity and reliability.

3) An accurate assessment may have been limited by the unwillingness of surveyed teachers to answer honestly, either out of concern over the impression it might present for their department or for Blaine Senior High.

4) An accurate assessment may have been limited by competition among departments.

5) Lack of knowledge regarding the interdisciplinary approach or confusion regarding its use as a curriculum reform might alter the results of the study.

6) The unbalanced ratio of technology to mathematics and science teachers may provide skewed results.

Definition of Terms

The following terms, which are relevant to the study and are used frequently throughout this entire document, are defined here for clarity:

Integrated Curriculum - Two or more teachers from different disciplines working together to coordinate their course instruction, develop materials, link academic and occupational skills, and develop varied instructional strategies (Wisconsin Department of Public Instruction, 1999).

Interdisciplinary Curriculum - A term that can mean any of the following:

1) Applying methods and language from more than one academic discipline to examine a theme, issue, question, problem, topic, or experience. Interdisciplinary curriculum creates connections between traditionally discrete disciplines such as mathematics, the sciences, social studies, or history, and English language arts. An interdisciplinary curriculum may be pursued by individual teachers working on a particular unit or among teachers planning together.

2) The process teachers use to organize and transfer knowledge under a united theme (Maurer, 1994).

STEM - A term that can mean any of the following:

1) The acronym for science, technology, engineering, and mathematics.

2) A type of curriculum that integrates science, technology, engineering, and mathematics in its approach.

3) A type of curriculum that integrates science, technology, English, and mathematics. This use is uncommon, and was found in the literature only once.

Technology - A term that can mean any of the following:

1) The material products of human fabrication "technics."

2) A distinctive form of human cultural activity whose practitioners include engineers, machinists, and many craftspeople.

3) The total societal enterprise devoted to the research, development, production, operation, and maintenance of technics and sociotechnical systems.

4) The process comprising the knowledge, materials, and methods used in making a particular kind of technic (a technology).

5) The use of critical thinking skills, resources, and the devices people have invented to solve problems (Thode, 1994).

Technology Education - A study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology (ITEA, 2000). Technology education is a discipline that involves knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage the man-made and natural environments for the purpose of extending human potential and the relationship of these to individuals, society, and the civilization process (Sterry & Wright, 1987).

Chapter II: Review of Literature

Introduction

This chapter will first examine the exponential growth of the human knowledge base and the impact of technological change on every aspect of society. Second, it will explore the pressures this has placed on the nation's education system, the impacts on American students, and implications for the future of our country. Third, a brief chronology of various education reforms that have attempted to address these problems will be presented. Reform efforts to be discussed include the growth of standards-based initiatives, the emergence of the education reform known as the interdisciplinary curriculum approach, and the subsequent appearance of engineering-based curricula in public schools. Fourth, research findings and examples of successful interdisciplinary approaches found in the literature will be presented. Next, a successful and exciting multi-disciplinary engineering curriculum will be featured using the Project Lead The Way curriculum being implemented at Blaine Senior High in Blaine, Minnesota as an example. The chapter concludes with evidence that indicates interdisciplinary approaches are not being widely implemented in the schools, despite support from research findings and overwhelming praise from students, parents, and teachers who are using interdisciplinary approaches.

The Knowledge Explosion

Cell phones, formerly a luxury that only the rich could afford, are now commonplace. Mass-production of hybrid electric vehicles has finally become economically feasible. We use the Internet to exchange information with people around the world, instantly and with a level of convenience that would have been unimaginable just a few years ago. The signs of technological change are all around us.

M. James Bensen alluded to the impact of technology when he stated, "The power and force of technology today is self-evident. It is fueling rapid change and global competition as never before" (Bensen, 1995, p. 261). As a result of this "power and force," we live in a world where advances in technology and science have altered nearly every aspect of daily life.

To see that this trend will likely continue, consider for a moment how much we know. Over ten thousand new scientific articles are published every day. The knowledge base is currently doubling every seven years, and the rate of increase is increasing (Bensen, 1995; Oblinger & Rush, 1997). There is so much information that educators are increasingly overwhelmed as they attempt to prioritize what they teach their students. Class time is a precious commodity and there is simply not enough time to teach everything. As society moves forward at an increasing pace, it will be increasingly difficult for education to adapt to the needs of a technologically advancing society.

The Impact on American Students

Complicating the problem is evidence that American education is already failing to keep pace with these rapid technological changes. Even more alarming, research has indicated that the failure has been occurring for some time. *A Nation at Risk: The Imperative for Educational Reform,* a study initiated in the 1980's by former Secretary of Education T. H. Bell and carried out by the National Commission on Excellence in Education (1983), indicated that America's education system was no longer superior in the global community. The study indicated that in international comparisons of student achievement on 19 academic tests, American students were never first or second. In comparison with other industrialized nations, American students were last seven times. The study also noted a national illiteracy rate of 13% among 17 year old students, with rates as high as 40% among minorities, and evidence that gifted and talented students were also exhibiting substandard performance.

It is not surprising that these problems follow students to college. When colleges use entrance surveys to establish a baseline for the skills of incoming college freshmen, their skills are much lower than expected - including their computer skills. Baylor University reported that only 24% of engineering students have any experience using Computer Aided Design (CAD) software, and their expertise level on a scale of one to five was at one. In addition, 31% of the students had experience with drafting, but again, the experience level was one. Only 63% of students were familiar with software like PowerPoint - also at an expertise level of one on a scale of one to five (DeJong, VanTreuren, Faris, & Fry, 2001). The observations made at Baylor University seem consistent with the course enrollment trends of American high school students. American students typically don't seek added rigor beyond required math and science courses.

The National Center for Improving Science Education (NCISE) addressed this issue and many others in a ground-breaking 1991 report entitled *The High Stakes of High School Science*, which produced a representation of the field consistent with the findings from over 300 reports addressing science education (NCISE, 1991). The NCISE reported that:

> At least two-thirds of the nation's high school students typically do not elect science courses or achieve well in those courses they are required to complete. These students are disproportionately women, minorities – African Americans, native Americans, native Alaskan Americans, Hispanic Americans – and low-income and non-college-bound Americans… even the student population best served by the current science education system – the college-bound – is getting short shrift. (NCISE, 1991, p. 1)

The NCISE further indicated that high school science curriculum is boring. It is unrewarding. It provides little or no hands-on activity or opportunity to experience or relate to live science. "The high school curriculum is characterized by strict disciplinary approaches to science that are limited to the body of knowledge with little attention to how that body of knowledge develops or how it makes an impact on culture and society" (NCISE, 1991, p. 1). Whittaker (1994) also addressed this issue, citing the lack of new and creative curriculum and pedagogy in mathematics, science, and technology education. Krieger had the harshest criticism of all:

> During the middle school years, a student's window to the natural world is typically a textbook accompanied by dreary worksheets. As a result, students enter high school thoroughly bored by science and give no thought to the subject beyond the required courses, which more often than not affirm their expectations of an unrewarding experience. (Krieger, 1992, p. 27)

It is therefore not surprising that student enrollment declines yearly in these classes beyond the state required courses (Whittaker, 1994). The NCISE report summed the situation up best when they said "science education simply is *not* working for the majority of American students" (NCISE, 1991, p. 1).

Addressing the Problem

Faced with exponential growth of the knowledge base, sharp criticism of the American educational system, and lack of student interest in critical subject areas, what are educators to do? How can they decide what to place priorities on in their teaching if they are to reverse these trends? Many educational reforms have attempted to answer these questions and address the findings of *A Nation at Risk* and *The High Stakes of High School Science.* Unfortunately, changes in education have almost always been uncoordinated because the changes have occurred within individual disciplines of study, rather than using a unified approach (Rossiter, 2002). Wicklein and Schell (1995, p. 59) described the consequences of using this approach to create better curriculum: "...school curricula is a segregated approach to instructional topics which does not adequately address the reassemblage of topics into a coherent body of knowledge to be used by students." The result is often that students spend most of their time on the lower end of Bloom's taxonomy, learning facts within individual disciplines at the knowledge level, rather than developing the higher level cognitive skills like application, analysis, synthesis, and evaluation across various disciplines. Many of these educational reforms have come forward in the form of educational standards. Rather than trying to dictate the means of instruction, standards attempt to establish desirable outcomes.

Standards Based Initiatives Emerge

According to Doolan and Honigsfeld (2000), the stunning inadequacies identified in *A Nation at Risk* have been largely responsible for the standards-based education reform movements of the last two decades. As noted by Childress, "most educational reform reports since the mid 1980's call for higher standards for curricula, higher standards for student achievement, and new approaches to teaching and learning" (1996, p. 16). In addition, Rossiter cited a report from the Council for Citizenship Education, indicating that recent years have witnessed serious efforts by national organizations, state education departments, and local school districts to restructure education from within the classroom by developing new standards for what students learn and how teachers teach (2002).

In 1994 President Clinton signed into law the *Goals 2000: Educate America Act*. The law supported state efforts to develop clear and rigorous standards for what every child should know and be able to do. Furthermore, it supported comprehensive state and district-wide planning and implementation of school improvement efforts focused on improving student achievement to meet those standards. The states have accepted this support readily. According to Marzano (1996) and the American Federation of Teachers (1999), standards development is underway or has been completed in 49 states for the core academic areas of math, science, English, and social studies. The National Research Council, through the National Committee on Science Education Standards and Assessment, has developed goals and guidelines for improving K-12 science education with the *National Science Education Standards* (NRC, 1996). The National Council of Teachers of Mathematics published the *Principles and Standards for School Mathematics* for pre-kindergarten through high school mathematics curriculum (NCTM, 2000). Technology education has responded by developing its own academic standards. This has happened nationally and, in some cases, at the state level. At the state level, Wisconsin produced Wisconsin's Model Standards for Technology Education. At the national level, the International Technology Education Association (ITEA) has led the way with the *Standards for Technological Literacy*. This comprehensive set of national technology education standards represents a consensus of experts regarding "the guidelines for what each person should know and be able to do in order to be technologically literate" (ITEA, 2000, p. 208).

One of the most striking changes in recent standards development initiatives has been the effort to improve student connections to real-world applications and to include multi-disciplinary perspectives. In the *National Science Education Standards*, the National Research Council stated the necessity for a multi-disciplinary approach as follows:

> The goal of science is to understand the natural world, and the goal of technology is to make modifications in the world to meet human needs. Technology as design is included in the *Standards* as parallel to science as inquiry.
>
> Technology and science are closely related. A single problem often has both scientific and technological aspects. The need to answer questions in the natural world drives the development of technological products; moreover, technological

needs can drive scientific research. And technological products, from pencils to computers, provide tools that promote the understanding of natural phenomena. (NRC, 1996, p. 24)

This body of work contains several standards that present a multi-disciplinary approach including: science as a mode of inquiry, science and technology, and science in personal and social perspectives (NRC, 1996). For example, the standards for science in personal and social perspectives for kindergarten through fourth grade read as follow:

Science in Personal and Social Perspectives

Content Standard F:

As a result of activities in grades K - 4, all students should develop understanding of

- Personal health
- Characteristics and changes in populations
- Types of resources
- Changes in environments
- Science and technology in local challenges. (NRC, 1996, p. 138)

The *Principles and Standards for School Mathematics* stressed the importance mathematics curricula emphasizing connections to other disciplines and real-world applications of mathematics concepts when it stated "an effective mathematics curriculum focuses on important mathematics that will prepare students for continued study and for solving problems in a variety of school, home, and work settings" (NCTM, 2000, p. 2). A significant number of the standards presented in the *Standards for Technological Literacy* emphasized the important interplay that takes place between science, math, engineering, society, and human history. Standards organized under the *Nature of Technology* heading are used to teach students in grades

K-5 about the relationships between technology and other fields of study (ITEA, 2000). Standards organized under the *Technology and Society* heading are used to teach students in all grade levels about the cultural, social, economic, and political effects of technology and the role of society in the development and use of technology (ITEA, 2000).

A Critical Time for Progress

These new efforts, which attempt to improve on past educational reforms that limited improvement to one specific discipline, couldn't come at a more important time. Many experts are deeply concerned that while our culture becomes increasingly technologically and scientifically oriented, that Americans are becoming less technologically and scientifically literate. Americans are losing their ability to understand the technology and science that underpin the high standard of living that many Americans enjoy, according to Cheek (1992). According to the National Science Foundation, in 2004 there were over 1,300,000 engineering or engineering technology jobs available in the U.S. without trained people to fill them (NSF, 2004). Science, math, and technology are a practical necessity for "understanding the natural environment and contemporary culture – particularly in an age when science and technology permeate U.S. life" (NCISE, 1991, p. 1). The NCISE further emphasized the need for this type of education for "maintaining a strong participatory democracy, strengthening a declining economy, and the achievement of science all demand a scientifically literate citizenry" (NCISE, 1991, p. 1).

Some have even expressed concerns about education within a national security context. In the foreword to Arthur M. Squires' book *This Tender Ship*, Harold C. Livesay expressed his concerns on this topic when he stated that "Maintenance of national well-being depends, at least in part, on a nation's ability to generate and adopt the technology necessary to maintain economic competitiveness and, in the case of the United States, a credible force with which to defend ourselves and our allies" (cited in Squires, 1986, p. xiii). Bensen expressed similar thinking when he stated, "The study of technology is imperative for the well-being of our nation and the common good of our people." (Bensen, 1995, p. 261). Perhaps the strongest language on the matter came from the U.S. Commission on National Security/21st Century, which stated:

> The scale and nature of the ongoing revolution in science and technology, and what this implies for the quality of human capital in the 21st century, pose critical national security challenges for the United States. Second only to a weapon of mass destruction detonating in an American city, we can think of nothing more dangerous than a failure to manage properly science, technology, and education for the common good over the next quarter century. (U.S. Commission on National Security/21st Century, 2001, p. 30)

Simply stated, there is a growing concern that chronic technological illiteracy will eventually bring about the downfall of Western civilization as we know it (Spiegel-Rosing & de Solla Price, 1977; Cheek, 1992).

To ensure that these dire predictions never come to pass, the leaders of tomorrow will need to fully comprehend the interplay between scientific and technological advancements and societal wants and needs. While science and technology clearly influence society, the multiple ways in which social systems and values impact the direction and progress of science and technology are often less obvious. A primary danger is that the average person does not have to understand science and technology to be passively effected by its impacts, but they do have to understand science and technology to actively use knowledge to meet their needs. For better or worse, this relationship has become one of the cornerstones of our participatory democracy, and it increasingly requires a knowledgeable, thinking, technologically literate populace.

Some believe that technology education is uniquely suited to create these knowledgeable thinkers. In many ways it is a logical fit. Technology education combines knowledge of mathematics and science with the study of human endeavors in creating and using tools, techniques, resources, and systems to manage man-made and natural environments for the purpose of extending human potential – as well as the relationship of these to individuals, society, and the civilization process (Sterry & Wright, 1987). In his rationale for technology education, *The Transition from Industrial Arts to Technology Education: the Content of the Curriculum*, Bensen presented a logical argument for using comprehensive technology education to meet the growing need for technologically literate citizens. He argued that "Students need Technology Education because, as citizens and consumers, they need to understand our technological culture. In order to make intelligent choices, we must be technologically literate" (Bensen, 1988, p. 168). Zuga echoed these sentiments when she wrote:

> Industrial technology education programs prepare students to function in our technological society. They provide application and immediate relevance to principles in math, science, and other subject areas. They focus on the development and application of industrial technologies, and they develop students who are self-learners and problem solvers, as well as self-reliant and productive members of society. (Zuga, 1987, p. 53)

Wright also argued that technology education should hold an equal place with science and math. He suggested that all three have common features, including a body of knowledge, mode of inquiry, and a history that holds both personalities and significant events (Wright, 1996). Technology education has the knowledge of practice, a mode of inquiry focused on the creation of new technologies, and an amazing and distinguished history beginning prior to the

Stone Age and leading to the present day. All technology is ultimately dependent on the creativity and ingenuity of the human mind (Rossiter, 2002).

A shared vision seems to be forming with regard to how students should be taught about science, math, technology, and society. The *National Science Education Standards*, the *Principles and Standards for School Mathematics*, and the *Standards for Technological Literacy* are manifestations of this growing consensus. To have established national standards for desirable outcomes in the areas of science, mathematics, and technology is a long overdue beginning that is producing results.

The Multidisciplinary Approach, STEM, and Engineering

Acting on the shared recommendations of these standards initiatives, many schools across the United States have begun to present a multi-disciplinary approach. This has been done predominantly through the adoption of an engineering-based curriculum to replace or augment the technology education curriculum (Lewis, 2004). As schools experiment with implementing engineering into their curriculum, it becomes obvious that while teachers can teach content with computers, educators can't teach content with just computers. Although teachers are doing more than they have in the past to give students opportunities to become technologically literate, too often educators place students in front of computers and assume that problem solving abilities and technological literacy follows (Gomez, 2004). Students need to be given exposure to the creative nature of engineering through design projects, hands-on laboratories, and open-ended problem solving (Sheppard & Jenison, 1996). The most compelling reason to utilize technology education to meet this need is that the defining feature of technology education's curriculum is its use and reliance on hands-on, experiential learning (Pearson & Young, 2002; Snyder, 2004).

This form of education connects science, technology, engineering, and math, commonly referred to as STEM, and may have a profound effect on how students view their educational experience. Students work hard during their entire school day. Every instructor (whether science, technology, engineering, or math) plays a significant role in the engineering program. The engineering program makes use of what students learn in every class, combines it, applies it, and provides the opportunity to solve real world problems and case studies. This closely matches the job description of what engineers do, since "engineers apply the theories and principles of science and mathematics to solve technical problems. Frequently the engineer's work makes the connection between scientific discovery and real-world application" (Deal, 1994, p. 15).

An early report that built momentum in the move towards engineering in technology education was the 1996 report *Technology For All Americans: A Rationale and Structure for the Study of Technology*, created by the Technology for All Americans Project (ITEA, 1996). The report argued for all students to be technologically literate and it laid the groundwork for the national standards that were to follow in 2000. The second big push to include engineering in the technology education curriculum occurred when the National Science Foundation provided the funding needed to create the *Standards for Technological Literacy* (ITEA, 2000).

The professional engineering community has been supportive of these efforts. It is not coincidental that the foreword of the *Standards for Technological Literacy* is written by William Wulf, president of the National Academy of Engineering (Lewis, 2004, p. 31). Ried and Feldhaus documented the significant efforts made by the American Society for Engineering Education to support growth and development of K-12 engineering curricula:

> Recently, the American Society for Engineering Education (ASEE) has embarked on an ambitious effort to promote and improve K-12 engineering and engineering technology education. Since 2003, the ASEE has created a new K-12 division dedicated to K-12 engineering education, created a guidebook for high school

> students called *Engineering, Go for It!* that was distributed to almost 350,000 secondary students, created an e newsletter that reaches 10,000 secondary teachers, guidance counselors, and outreach program leaders, and created a survey to understand what secondary teachers think of engineering as an academic and career pathway for their students. Finally, ASEE brought together leaders from industry and higher education along with K-12 teachers for a Leadership Workshop on K-12 Engineering Outreach, held just before the ASEE 2004 Annual Conference and Exposition in Salt Lake City, Utah. A recent paper detailing the results of that conference and delineating guidelines for how K-12 engineering education works best and defines key challenges confronting the field was recently published.
>
> Clearly, there is a movement by the engineering and engineering technology communities to gain a better understanding of the K-12 issues that impact enrollment at post-secondary institutions, and to generate research to answer the question of how stakeholders from many levels – K-12 teachers, university professors, industry, and government representatives – can advance the state of engineering and engineering technology education. (Ried & Feldhaus, 2007, p. 6)

In addition, The National Research Council of the National Academy of Engineering sponsored a report published in 2002 entitled *Technically Speaking: Why All Americans Need to Know More About Technology*. The findings of the report were extremely supportive of teaching engineering design in the nation's technology education classrooms. The technology education classroom was a logical choice, they argued, since a technically literate person needs to understand engineering design: "An especially important area of knowledge is the engineering design process, of starting with a set of criteria and constraints and working toward a solution-a device, say, or a process--that meets those conditions" (Pearson & Young, 2002, p. 13). Pearson and Young went on to describe the technically literate person as one who understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.

The Project Lead The Way (PLTW) model is arguably the most prominent version of high school engineering curriculum being implemented today. PLTW is now offered in nearly 3,000 schools in all 50 states and the District of Columbia. More than 250,000 middle school and high school students are enrolled in the classes (PLTW, 2008). The course sequence is comprised of three key components, namely, mathematics, science, and technology education, with strong emphasis on engineering careers (Lewis, 2004). PLTW offers three course-sequence options in grades 9 through 12: foundation courses, specialization courses, and a capstone course. In each year of high school, students take at least one engineering course along with mathematics, science, English, social studies, physical education, and (except for grade 12) a foreign language.

All PLTW students are required to complete the foundation courses Introduction to Engineering (grade 9) and Principles of Engineering (grade 10) to prepare them for the later courses. Introduction to Engineering and Principles of Engineering are exploratory in nature, and are intended to help students learn about engineering careers by understanding what engineers and technicians do, and how they use math and science (Project Lead the Way, 2007-2008a). An optional foundation course available to interested students is Digital Electronics. As juniors, the students choose a specialization course by registering for at least one of the four engineering courses, including Aerospace Engineering, Biotechnical Engineering, Civil Engineering and Architecture, and Computer Integrated Manufacturing. Senior PLTW students choose a course of study for the capstone course entitled Engineering Design and Development (Project Lead the Way, 2007-2008a).

Interdisciplinary Approaches in the Literature

Several studies support the benefits of incorporating a multi-disciplinary curriculum. Research in the area of education, as well as in cognitive science, suggests that curriculum variations featuring an inter-disciplinary curriculum are likely to promote more learning (Loepp, 1999). Wicklein and Schell (1995) performed four separate case studies using a multi-disciplinary approach to mathematics, science, and technology education. The goals of these case studies included increasing the interest level of the students in these subject areas, to help teachers to understand that their particular instructional areas did not stand alone within the curricular offerings, to improve students' attendance in school, and to transfer learning to unique problems.

Through the application of "hands-on and minds-on" curriculum, the students understood the practical uses of the three instructional areas (Project Lead the Way, 2007-2008b). For example, students were able to see direct applications of math and science to their everyday life through a variety of technology-based activities. Students demonstrated more motivation by reducing their absences from school and discipline problems based on the school records from the previous year. Furthermore, students demonstrated an appreciation for the structured learning activities, were able to perceive the importance of working together to solve a common problem, were able to appreciate the occupational strategies of modern businesses and industries, and demonstrated an improvement in self-esteem (Wicklein & Schell, 1995; Rossiter, 2002).

The findings from this case study were not limited to student improvements. Faculty agreed that a multi-disciplinary approach created a learning atmosphere that provided students with a unique opportunity to learn in a much broader context. In addition, it allowed them to teach more effectively by revealing that students had been trained to dismiss subject matter learned in one classroom as having little or no relevancy to another.

The findings of the Wicklein and Schell (1995) case studies were consistent with the findings of Vars (1965) and Jacobs (1989). Vars reported that motivation for learning increased when students worked on real-problem elements. When students were actively involved in planning their learning and in making choices, they were more motivated and exhibited fewer behavior problems. Jacobs noted that a multi-disciplinary curriculum was consistent with increased self-direction, improved attendance, higher levels of homework completion, and a more positive outlook towards school and academics. Inter-disciplinary education curriculum helped students make connections, solve problems using multiple related activities, and to incorporate information from different fields (Lake, 1994).

The PLTW approach has also been tremendously successful, as have other multi-disciplinary approaches that integrate science, technology, engineering, and math (STEM) to teach students advanced concepts about the technological world around them. By all accounts, PLTW is introducing many students to engineering and technology who may not otherwise be exposed to engineering or technology. Part of the success of PLTW may be that it incorporates many changes recommended in the standards and by multi-disciplinary curriculum researchers. PLTW calls their approach activities-based learning, project-based learning, and problem-based learning or APPB-learning (PLTW, 2007-2008b). PLTW goes on to say:

> PLTW's curriculum makes math and science relevant for students. By engaging in hands-on, real-world projects, students understand how the skills they are learning in the classroom can be applied in everyday life. This approach is called or APPB-learning.

> Research shows that schools practicing APPB-learning experience an increase in student motivation, an increase in cooperative learning skills and higher-order thinking, and an improvement in student achievement. (PLTW, 2007-2008b, p. 1)

This instructional philosophy is consistent with the recommendations of numerous researchers who expressed widespread agreement that the defining feature of technology education's curriculum, and the reason it is so effective, is the use of and reliance on hands-on, experiential learning. The researchers also agreed that this was the most compelling reason to utilize technology education to meet current instructional needs (Zuga, 1987; Wicklein & Schell, 1995; Pearson & Young, 2002; Rossiter, 2002; Snyder, 2004).

With added requirements for rigorous teacher training, counselor training, school certification, curriculum, and required laboratory equipment, the PLTW program offers a standard of high quality and consistency. Students and parents have described the program as valuable and challenging, and industrial advisory board members have praised the program during visits. PLTW and similar programs should increase the pool of students ready, willing, and able to enter engineering and technology career fields after high school, either directly or via post-secondary educational programs (Ried & Feldhaus, 2007, p. 11).

One Example - Project Lead The Way at Blaine Senior High

Independent School District 11, the largest district in Minnesota, has implemented the Project Lead The Way model to integrate math, science, and technology education in one of its five regular high schools, Blaine Senior High. This was accomplished by establishing a Center for Engineering Math and Science (CEMS) at Blaine Senior High. CEMS enrolls a limited number of interested students into an interdisciplinary curriculum that combines required math and science courses with elective engineering courses. Since the program is elective in nature, the interdisciplinary curriculum influences around ten percent of Blaine High School students in each grade level, as currently implemented. Since the other five high regular schools in the district do not offer any PLTW classes, or any other type of integrated math, science and engineering curriculum, this experience will only be available to students willing to attend Blaine Senior High.

Theory and Practice – Separate Realities

Considering the widespread praise from parents and students, support from experts in the field, and research evidence that integrated STEM curricula are successful, it seems curious that there is so little application. This is true in many cases. Throughout the 1990's, curriculum integration and its application has been a consistent and important theme in education reform strategies, yet very few schools have adopted this reform in practice (Wisconsin Department of Public Instruction, 1999). This is unfortunate. It has occurred despite praise from parents and students who describe the interdisciplinary approach as valuable and challenging (Ried & Feldhaus, 2007); despite recommendations from numerous experts in the field and standards initiatives in science, math and technology described in this document that that call for implementation of a multi-disciplinary approach; and despite research that shows integrating the math, science, and technology education curriculum helps students across a wide range of academic achievement (Bailey, 1997; Wicklein & Schell, 1995).

Chapter III: Methodology

Introduction

In the following chapter, information concerning the subjects, sample selection, the survey instrument, data collection, method of results analysis, and survey limitations will be presented.

Subjects and Sample Selection

The research study was conducted at Blaine Senior High. The style of research was selected to gather information on perceptions and attitudes of a sample of teachers toward the educational reform of interdisciplinary curriculum. The population in this study consisted of mathematics, science, and technology education teachers at Blaine Senior High.

Two criteria had to be met to be included in the sample. First the subject had to be a teacher at Blaine Senior High. Second, the subject had to hold a valid Minnesota teaching license in mathematics, science, or technology education at the time of the study. In all, there were fifteen mathematics, fifteen science, and ten technology teachers who met the criteria which formed a group cluster of forty subjects.

Instrument

A confidential survey was designed by the researcher based on a model developed by Daniel J. Rossiter (Rossiter, 2002). The style of survey was selected based on three factors. First, the subjects were composed of teachers in various disciplines, and as such could not provide an appropriate number of responses to do a correlational study. Second, it was noted that studies researching attitudes and opinions on a topic were most commonly investigated using a Likert scale as a measuring instrument. Third, no existing instrument was found that could successfully obtain the desired data.

As a result, a researcher generated survey was created that was specifically suited to collect data pertinent to the research questions of the study. While the instrument lacked documented validity and reliability, it was the most feasible way to obtain the desired data. A copy of the survey is available in Appendix A.

The survey consisted of a four page booklet. The first page served as a cover page and explained four key items. First, it described the research being conducted. Second, it explained how to return the survey to the researcher. Third, it served as a consent form informing the participants of their rights. Finally, it provided contact information for personnel at the University of Wisconsin-Stout where any subject could direct any concerns or questions about the research being conducted. Pages two, three, and four consisted of nominal questions on subject demographics and ordinal questions related to the participant's attitudes and perceptions of an interdisciplinary curriculum.

The majority of the questions on the survey used a five point Likert scale measuring system, which allowed for a wide range of attitudes and opinions. Information and instructions were provided about how the Likert scale is used to measure perceptions and how to use the Likert scale (Likert, 1932). The Likert scale questions asked the teachers to choose one of the following responses for each question: strongly disagree, disagree, no opinion, agree, or strongly agree. The survey also had an area for subject comments.

Data Collection

On February 16, 2009, the researcher placed a survey in each subject's school mail box. The participants in this study were given a period of ten school days to complete and return the survey. On February 23, 2009, the researcher e-mailed all subjects thanking them for taking part in the study, also reminding them that they still had time to turn in the survey by February 27, 2009 if they had not done so already. See Appendix B for survey notification.

Data Analysis

On March 1, 2009 data collected from the subjects in this study was analyzed. Teacher responses were tabulated for frequencies, percentages, and cross-tabulations from the twenty questions on the survey. This was done by assigning a value for each question. Nominal questions were given a number to identify such things as gender, discipline currently teaching, years teaching current discipline, years in the school district, level of education, and grade level taught. For example, on the question dealing with gender, female responses were given a value of (1) and male responses were given a value of (2). The ordinal Likert scale questions were measured the following way: strongly disagree value was (1), disagree value was (2), no opinion had no value (0), agree value was (4), and strongly agree value was (5). Consequently, subject responses ranged between 0 and 5. The teacher responses were then used to answer the research questions.

Limitations

Several limitations were identified, with similarity to the limitations noted in the first chapter. The identified limitations are:

1) The sampling of teachers was limited to mathematics, science, and technology teachers at Blaine Senior High, resulting in a small sampling group. This might limit the usefulness of the results outside Blaine Senior High.

2) The survey was generated by the researcher. As a result, it lacked documented validity and reliability.

3) An accurate assessment may have been limited by the unwillingness of surveyed teachers to answer honestly, out of concern over the impression it might present for their department or for Blaine Senior High.

4) An accurate assessment may have been limited by competition among departments.

5) Lack of knowledge regarding the interdisciplinary approach or confusion regarding its use as a curriculum reform might alter the results of the study.

6) The unbalanced ratio of technology to mathematics and science teachers may provide skewed results.

Chapter IV: Results

Introduction

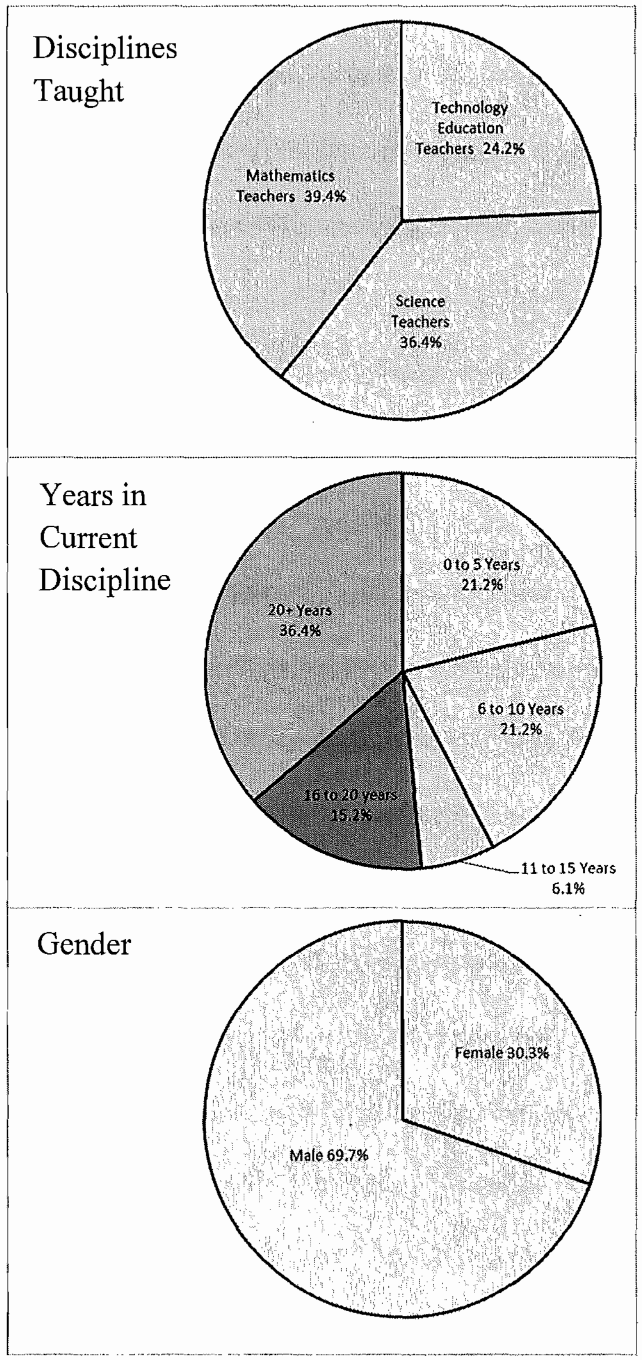
This chapter will present the results of the study. Specifically, this chapter will present information about mathematics, science, and technology education teachers at Blaine Senior High and their perceptions of an interdisciplinary curriculum to replace the current curriculum. The primary purpose of the study was to gather this information as part of a feasibility study for the implementation of an interdisciplinary curriculum for all students at Blaine Senior High.

Demographics

The subjects in this study were mathematics, science, and technology education teachers from Blaine Senior High. The following is the information gathered from the completed surveys that were returned.

Of the 40 surveys sent out, 33 were returned, yielding a return rate of 82.5%. Mathematics teachers returned 13 of 15 surveys, totaling 39.4% of the subjects; science teachers returned 12 of 15 surveys, totaling 36.4% of the subjects; and technology teachers returned 8 of 10 surveys, totaling 24.2% of the subjects. See Figure One for a graphic depiction of teacher disciplines comprising the sample. As anticipated, years of teaching their discipline and years of teaching at Blaine Senior High varied widely among the subjects. Seven teachers (21.2%) have spent five years or less teaching their current discipline, seven teachers (21.2%) have six to ten years teaching their current discipline, two teachers (6.1%) have eleven to fifteen years teaching their current discipline, five teachers (15.2%) have 16-20 years teaching their current discipline, and twelve teachers (36.4%) have at least twenty years of teaching experience in their current discipline. See Figure One for a graphic depiction of teacher disciplines comprising the sample. Of these individuals, eight teachers (24.2%) have spent five years or less in the school district, eleven teachers (33.3%) have been in the school district six to ten years, two teachers (6.1%) have been in the school district eleven to fifteen years, two teachers (6.1%) have been in the school district sixteen to twenty years, and ten teachers (30.3%) have been in the school district twenty years or more.

Figure One: Selected Demographics of the Sample



Level of education obtained by the subjects included eight (24.2%) who currently have a BA/BS degree and twenty-five (75.8%) who hold a MS/MA degree. None of the subjects held a degree higher than an MS/MA at the time of the study. The gender breakdown of the study sample was ten females (30.3%) and twenty-three males (69.7%). See Figure One for a graphic depiction of the gender breakdown of the sample. Finally, twenty-four teachers (72.7%) teach ninth graders, twenty-eight teachers (84.8%) teach tenth graders, twenty-seven teachers (81.8%) teach eleventh graders, and twenty-six (78.8%) teach twelfth graders. Twenty-eight of the subjects (84.8%) teach multiple grade levels.

Research Questions

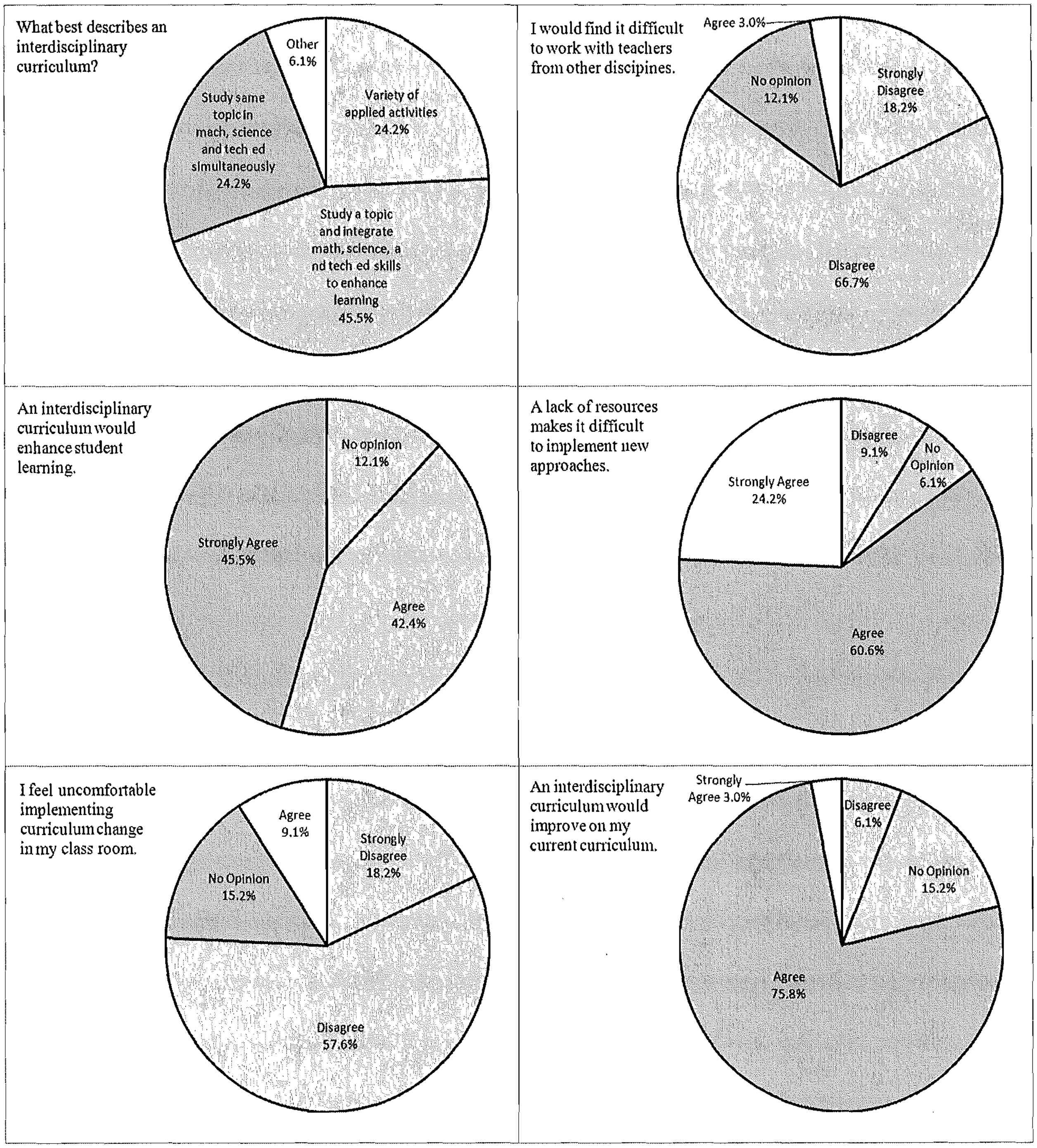
1) What is the main concept that defines an interdisciplinary curriculum?

Approximately 24.2% of the subjects surveyed felt that an interdisciplinary curriculum was a curriculum that used a central topic in mathematics, science, and technology classes simultaneously to enhance students' learning experience. The predominant opinion, shared by 45.5% of the subjects, was that an interdisciplinary curriculum was designed to integrate mathematics, science, and technology skills into a topic to enhance students' learning. Another group, comprising 24.2% of the subjects, felt an interdisciplinary approach was characterized by using a variety of applied activities while studying a topic to enhance student learning. Finally, a small group comprising 6.1% of the sample, felt that none of these descriptions described an interdisciplinary curriculum. See Figure Two for a graphic depiction of subject responses to this survey item.

2) What elements should be included in an interdisciplinary curriculum?

The largest number of subjects believed that an interdisciplinary curriculum should contain cross-discipline themes (87.9%) and exploratory activities (87.9%). There was also widespread agreement that a broad range of assessment strategies (84.8%), instructed laboratory activities (84.8%), and emphasis on problem solving (81.8%) should be included. Over three quarters of the sample also felt that goal-oriented instruction (75.8%) and cooperative learning (75.8%) were important components. Two thirds of the subjects believed that an interdisciplinary curriculum should have writing activities (66.7%) and verbal activities (63.6%). Cognitive strategies, reading activities, and hypothesis-driven activities were included by 60.6% of the sample, with student teams being the least popular (57.6%). One subject used the location for other comments to indicate that developing study skills (3.0%) was an important component for an interdisciplinary approach.

Figure Two: Sample Responses to Selected Survey Items



3) Do current curricula contain elements, either planned or unplanned, which are consistent with an interdisciplinary approach?

Nine teachers agreed and one teacher strongly agreed (30.3%) that their current curriculum contained elements of an interdisciplinary curriculum, but that they were unplanned.

Twenty-one teachers (63.6%) disagreed, indicating that the interdisciplinary elements of their curriculum were intentional. Similarly, twenty-three teachers agreed and one strongly agreed (72.7%) that they purposely include material from other disciplines in their current curriculum. Six teachers disagreed and one strongly disagreed (21.2%) that they purposely include material from other disciplines in their current curriculum. Two teachers (6.1%) had no opinion on whether their current curriculum contained elements, either planned or unplanned, of an interdisciplinary approach.

4) Would an interdisciplinary curriculum of mathematics, science, and technology enhance student learning?

An overwhelming number of subjects (87.9%) felt that an interdisciplinary curriculum would enhance student learning. Of the subjects, 42.4% agreed and 45.5% strongly agreed that an interdisciplinary curriculum would enhance student learning. The remaining 12.1% had no opinion. None of the teachers disagreed or strongly disagreed with the statement that an interdisciplinary curriculum would enhance student learning. See Figure Two for a graphic depiction of subject responses to this survey item.

5) Would an interdisciplinary curriculum of mathematics, science, and technology improve upon the current curricula for mathematics, science, and technology education?

Based on the response to the previous question it was not surprising that an overwhelming number of subjects (78.8%) also felt that an interdisciplinary curriculum would improve on their current curriculum. Of the remaining subjects 15.2% had no opinion and two subjects (6.1%) disagreed that an interdisciplinary curriculum would improve on their current curriculum. None of the subjects strongly disagreed that an interdisciplinary curriculum would improve on their current curriculum. See Figure Two for a graphic depiction of subject responses to this survey item.

6) How comfortable are teachers with implementing curriculum change in their classrooms?

An overwhelming number of subjects (75.8%) felt comfortable implementing curriculum change in their classroom. Among the sample, 57.6% agreed and 18.2% strongly agreed that they felt comfortable implementing curriculum change in their classroom. Of the remaining subjects, 15.2% had no opinion and 9.1% agreed they were not comfortable implementing curriculum change in their classroom. None of the subjects strongly agreed that they would be uncomfortable implementing curriculum change in their classroom. See Figure Two for a graphic depiction of subject responses to this survey item.

7) Does a lack of time, money, or other resources make it difficult to implement an interdisciplinary curriculum?

A large segment of the sample (84.8%) felt that a lack of time, money, or other resources made it difficult to implement an interdisciplinary curriculum. Of the subjects, 60.6% agreed and 24.2% strongly agreed that an interdisciplinary curriculum would enhance student learning. Of the remaining subjects, 6.1% of had no opinion and 9.1% disagreed. None strongly disagreed that a lack of time, money, or other resources made it difficult to implement an interdisciplinary curriculum. See Figure Two for a graphic depiction of subject responses to this survey item.

Over half the sample felt that their professional training was insufficient to use an interdisciplinary approach. Of the 18 subjects who felt this way, 51.5% disagreed and 3.0 % strongly disagreed that their professional training prepared them to use an interdisciplinary approach. Among the 27.2% who felt their professional training did prepare them to use an interdisciplinary curriculum, 24.2% agreed and 3.0 % strongly agreed. The remaining 18.2% expressed no opinion.

An overwhelming number of subjects (78.8%) agreed they would be willing to learn the basic concepts of an interdisciplinary curriculum, with 63.6% in agreement and 15.2% in strong agreement. The remaining seven subjects (21.2%) expressed no opinion on whether they would be willing to learn the basic concepts of an interdisciplinary curriculum. None of the subjects was unwilling to learn the basic concepts of an interdisciplinary curriculum.

8) Is there a difference in attitude between the mathematics, science, and technology education teachers toward the implementation of an interdisciplinary curriculum?

Averaged responses from teachers about their attitude toward the implementation of an interdisciplinary curriculum ranged from 2.78 to 4.67 out of a range of 1 to 5. Of the thirty-three subject responses the mode was established by seven teachers with an averaged response of 4.00. The median value of averaged responses for all teachers was 3.78, with twelve subjects (36.4%) below the median, five subjects (15.2%) at the median, and sixteen subjects (48.5%) above the median. The mean value of averaged responses for all teachers was 3.81, with eighteen subjects (54.4%) below the mean and fifteen subjects (45.5%) above the mean.

A cross-tabulation analysis of mathematics, science, and technology education teacher responses yielded the following results: The modes for the thirteen mathematics teacher group were established by two groups of three subjects, with modal values of 3.56 and 4.00. The median value for this group was 3.89, with six subjects (46.2%) below the median, one subject (7.7%) at the median, and six subjects (46.2%) above the median. The mean value was 3.84, with six subjects (53.8%) below the mean and seven subjects (46.2%) above the mean.

The modes for the twelve science teacher group were established by three groups of two subjects, with modal values of 3.56, 3.78, and 4.11. The median value for this group was 3.78, with five subjects (41.7%) below the median, two subjects (16.6%) at the median, and five subjects (41.7%) above the median. The mean value was 3.75, with seven subjects (58.3%) below the mean and five subjects (41.7%) above the mean.

The modes for the eight technology education teacher group were established by two groups of three subjects, with modal values of 3.78 and 4.00. The median value for this group was 3.89, and the mean value was 3.85. Technology teachers were evenly split around both the mode and median, with one group of four subjects below the mean and the median and the other four subjects above.

9) Do teacher perceptions of other curricular areas make them more or less likely to cooperate in an interdisciplinary curriculum?

The sample soundly rejected the notion that it would be difficult for them to work with teachers from other disciplines, with 84.8% stating that they disagreed (66.7%) or strongly disagreed (18.2) that they would find collaboration difficult. Of the remaining subjects, 12.1% had no opinion and only one subject (3.0%) agreed. No one strongly agreed that collaboration with teachers from other disciplines would be difficult. See Figure Two for a graphic depiction of subject responses to this survey item.

The sample responded in a similar fashion when asked if an interdisciplinary approach would waste valuable class time in their discipline area. Of the population, 75.8% disagreed with the notion that an interdisciplinary approach would waste class time in their discipline area, with 66.7% stating that they disagreed and 9.1% stating that they strongly disagreed. Of the remaining subjects, three (9.1%) agreed that an interdisciplinary approach would waste class time in their discipline area and 15.2% had no opinion. However, no one strongly agreed that collaboration with teachers from other disciplines would waste valuable class time in their discipline area.

In a related question, the population responded with less agreement when asked if their discipline area was more important than others involved in the study. Of the sample, 60.6% disagreed with the notion that their discipline area was more important than others involved in the study, with 54.5% stating that they disagreed and 6.1% stating that they strongly disagreed. Three subjects (9.1%) felt that their discipline area was more important than others involved in the study, with two respondents (6.1%) agreeing and one (3.0%) respondent strongly agreeing. Ten respondents, or 30.3%, had no opinion.

When asked if other discipline areas valued their discipline and would be interested in an interdisciplinary curriculum with their subject area, 57.6% of the sample felt that their discipline was valued by others. Among this group, 48.5% disagreed and 9.1% strongly disagreed that teachers in other curricular areas didn't value their curricular area and therefore would not be interested in an interdisciplinary approach with their subject area. Of the remaining subjects, 15.2% agreed that teachers in other curricular areas didn't value their curricular area and therefore would not be interested in an interdisciplinary approach with their subject area and 27.3% had no opinion.

10) Does required curriculum such as graduation standards make it difficult to implement an interdisciplinary curriculum?

Two thirds of the sample, 66.7%, agreed that required curriculum such as graduation standards would make it difficult to implement an interdisciplinary curriculum. Within this group, 60.6% agreed and 6.1% strongly agreed. Approximately one quarter, 24.2%, of the sample disagreed, with 21.2% stating that they disagreed and one respondent (3.0%) stating he or she strongly disagreed. Three teachers (9.1%) had no opinion whether required curriculum elements such as graduation standards would make it difficult to implement an interdisciplinary curriculum.

11) Would an interdisciplinary curriculum support the learning goals of our high school?

An overwhelming number of subjects (78.8%) felt an interdisciplinary curriculum would support the learning goals of Blaine High School. Within this group, 75.8% agreed and 3.0% strongly agreed. Of the remaining subjects, 15.2% had no opinion and 6.1% disagreed that an interdisciplinary curriculum would support the learning goals of Blaine High School. None of the subjects strongly disagreed that an interdisciplinary curriculum would support the learning goals of Blaine High School.

12) Do current curricula provide a holistic learning experience?

Teachers were less confident that their current curriculum provided a holistic learning experience. Of the sample, 51.5% felt that their curriculum provided a holistic learning experience. Within this group, 39.4% agreed and 12.1% strongly agreed. Six teachers (18.2%) disagreed that their current curriculum gave students a holistic learning experience. Ten teachers (30.3%) had no opinion on whether their current curriculum gave students a holistic learning experience. None of the subjects strongly disagreed that their current curriculum gave students a holistic learning experience.

Chapter V: Summary, Conclusions, and Recommendations

Introduction

In the following chapter, conclusions based on the literature review and the results of the study will be presented. In addition, recommendations which build on the work done thus far will be set forth and areas that would benefit from further study will be identified.

Summary

This study was developed to obtain mathematics, science, and technology teachers' perceptions and attitudes towards an interdisciplinary curriculum at Blaine Senior High. A survey was developed by the researcher to collect the research data. Voluntary responses were solicited from forty teachers at Blaine Senior High. All forty Blaine Senior High mathematics, science, and technology education teachers were invited to participate. The majority of the questions on the survey used a five point Likert scale measuring system, which allowed for a wide range of attitudes and opinions. Thirty-three teachers elected to participate in the study by returning the surveys via school mail. Responses were analyzed and recorded by the researcher. While analyzing the data, an understanding was developed of how teachers from each of the three disciplines viewed such a curriculum. Data was recorded using two different methods: percentages and cross-tabulations.

Conclusions

Although the sample was relatively small, some patterns were observed in the way teachers think about interdisciplinary approaches in their curriculum. In addition, results from the study were consistent with the results of other research found in the literature. Interdisciplinary education is an educational reform suffering from an identity crisis. When the sample was confronted with three very different choices for what an interdisciplinary curriculum might entail, there was no consensus on which description best captured the essence of an interdisciplinary approach. Approximately half of the subjects believed an interdisciplinary approach involved studying a topic and integrating math, science, and technology skills to enhance learning. About one quarter of the subjects believed an interdisciplinary approach involved studying a topic and using a variety of applied activities to enhance the learning experience. The remaining one quarter believed an interdisciplinary approach involved studying the same central topic in math, science, and technology simultaneously to enhance the learning experience. To put it simply, at best over half the teachers don't agree on what an interdisciplinary curriculum is, and at worst three quarters of them don't agree.

These findings are consistent with existing research found in the literature, notably two separate studies done by Fogarty and Rossiter. They concluded that a primary source of confusion hampering the use of interdisciplinary curricula lies within the name (Fogarty, 1991; Rossiter, 2002). To make the interdisciplinary approach work, teachers and researchers must come to a consensus in defining what an interdisciplinary curriculum truly entails, and then label it in a way that is conceptually consistent with that definition.

Although it has proven difficult to describe the interdisciplinary approach in a way that fosters consensus, there was agreement on several elements that should be included in an interdisciplinary curriculum. There was also widespread agreement that a broad range of assessment strategies, instructed laboratory activities, and an emphasis on problem solving should be included. These findings were consistent with the work of Vars (1991), Wicklein and Schell (1995), and subsequently Tchudi and Lafer (1996).

It was extremely encouraging that an overwhelming number of subjects felt an interdisciplinary curriculum would improve on their existing curriculum and enhance student learning. Expectations of improved student performance are consistent with the findings of Arhar (1997), as well as Vars and Beane (2000). In *Integrative Curriculum in a Standard-Based World,* Vars and Beane stated:

> However, recent analyses of studies point to the same general conclusion: Almost without exception, students in any type of interdisciplinary or integrative curriculum do as well as, and often better than, students in a conventional departmentalized program. These results hold whether the combined curriculum is taught by one teacher in a self-contained or block-time class or by an interdisciplinary team. (p. 1)

In addition to optimism that an interdisciplinary approach would produce results, over three quarters of teachers in the study felt comfortable implementing curriculum change in their class rooms. Furthermore, an overwhelming number of subjects agreed they would be willing to be trained to learn the basic concepts of an interdisciplinary curriculum. The cross-tabulation analysis revealed that all three disciplines were in favor of a cooperative interdisciplinary curriculum. On a scale ranging from 0 to 5, all three disciplines were well above the median value of 3.0, indicating support of an interdisciplinary curriculum. Technology education and mathematics expressed the highest overall interest with mean responses of 3.85 and 3.84, respectively. Science expressed a slightly lower interest, with a mean response of 3.75. It was interesting that only science teachers agreed that their discipline area was more important than other disciplines in the study, with three subjects (25%) of the science faculty agreeing or strongly agreeing. This attitude contributed to their slightly lower support for an approach involving other disciplines. It was also noted that over half of the technology education teachers shared the perception that faculty in other disciplines viewed technology education as less important. What is interesting is that not even one math or science teacher felt that their curriculum area was not valued by others. It would be interesting to see if working together using an interdisciplinary approach would increase the perceived value of other curricular areas. This phenomenon was observed among teachers from Missouri and Nebraska working cooperatively on an interdisciplinary curriculum (Wicklein & Schell, 1995).

While these perceptions among teachers regarding the relative importance of various curriculum areas may pose some barriers to cooperative development, the preliminary findings indicated that teachers were supportive of using an interdisciplinary approach and they considered it a viable option for curriculum reform at Blaine Senior High.

Teachers in this study agreed overwhelmingly that lack of resources, such as time and money, were barriers to the implementation of an interdisciplinary curriculum - or any other curriculum reform. Two thirds of the sample felt the need to focus on required curriculum and achievement initiatives, such as student proficiency testing and graduation standards, would make it difficult to implement an interdisciplinary curriculum.

This was consistent with the findings contained in *Integrative Curriculum in a Standard-Based World*, which noted deterrents to interdisciplinary curriculum implementation (or any other type of curriculum reform) included the fact that most state standards and proficiency tests are set up in terms of conventional subject areas, such as reading, mathematics, science, or social studies (Vars & Beane, 2000). Another problem noted in the study was the sheer number of competencies specified in curriculum standards. Findings documented in *Integrative Curriculum in a Standard-Based World* indicated that it would take even a very competent student approximately nine additional years in school to reach acceptable performance in all of the standards recommended by national organizations (Vars & Beane, 2000).

Recommendations

The findings of this study, supported by existing research and recommendations identified in the literature, suggest that an interdisciplinary curriculum would be welcome at Blaine Senior High, and that it would be beneficial to students. As a result, the following recommendations were made to Blaine Senior High faculty and school district administrators regarding the implementation of an interdisciplinary curriculum at Blaine Senior High:

1) Perform a financial analysis to determine whether implementing an interdisciplinary curriculum of mathematics, science, and technology education for all students at Blaine Senior High is financially feasible.

2) Utilize staff development funds to educate teachers and administrators about the key concepts of an interdisciplinary curriculum. Establishing a clear consensus on what constitutes an interdisciplinary curriculum would be vital to future progress in the implementation of an interdisciplinary curriculum.

3) Allow mathematics, science, and technology education teachers to collaborate on the development of an interdisciplinary unit. Implement the unit. Solicit teacher and student perceptions upon completion of the unit.

4) Allow mathematics, science, and technology education teachers to collaborate on the development of an interdisciplinary unit. Implement the interdisciplinary unit for some students, then compare student performance on identical assessments of the material presented.

5) Enhance Minnesota graduation requirements to promote compatibility with interdisciplinary curricula.

Areas for Further Study

The findings and limitations of this preliminary study were valuable in identifying the following areas in which further research may be desirable:

1) Conduct a larger study to include mathematics, science, and technology education teachers to characterize teacher perceptions throughout the Anoka-Hennepin District.

2) Conduct a similar study to characterize perceptions of school administrators regarding the implementation of an interdisciplinary curriculum of mathematics, science, and technology education.

3) Conduct a study which explains key concepts of the interdisciplinary approach and the differences between interdisciplinary curricula and traditional curricula, and subsequently solicits parent and student perceptions about which curriculum approach they might prefer.

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Appendix A: Survey Instrument

Consent to Participate In UW-Stout Approved Research

Title: Perceptions of Science, Mathematics, and Technology Education Teachers on Implementing an Interdisciplinary Curriculum at Blaine Senior High

Investigator: John A. Bayer, Blaine High School, Technology Education, Room 123, x66713

Research Sponsor: Dr. Amy Gillett, UW Stout, 427 McCalmont Hall, (715) 232-2680

Description: The purpose of this study is to determine the interest of the mathematics, science, and technology teachers at Blaine Senior High regarding the development and implementation of an inter-disciplinary curriculum in their building.

Teachers of each discipline will be able to convey thoughts, attitudes, and ideas regarding what a successful inter-disciplinary curriculum of mathematics, science, and technology education would look like and what obstacles would need to be overcome to implement such a curriculum. The findings may be used in the planning of the implementation of mathematics, science, and technology inter-disciplinary curriculum.

The study will also clarify differences between traditional curricula and inter-disciplinary curricula. It will show how an inter-disciplinary approach seeks to develop the student in a more complete and integrated approach through active learning. In contrast, traditional curricula pours the knowledge into the students like empty vessels (Tchudi & Lafer, 1996; Illich, 1970). This information will be useful in planning the implementation of mathematics, science, and technology inter-disciplinary curriculum.

Risks and Benefits: The primary benefit is of the study collection of information to help identify advantages for and barriers to implementation of an inter-disciplinary approach to science, mathematics, and technology curriculum at Blaine High School. This will help Blaine High School better meet the changing needs of its dynamic student body . There is no apparent risk to the participants in their participation in this study. None of the information is anticipated to be upsetting to the participants.

Special Populations: No special populations will be used in this study.

Time Commitment: The survey will take approximately 10 minutes to complete.

Confidentiality: No names will be collected, therefore names will not be included on any documents. We do not believe that any subjects can be identified from the information collected in this study.

Right to Withdraw: Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences. However, should you choose to participate and later wish to withdraw from the study, there would be no way to identify your anonymous document after it has been turned into the investigator.

IRB Approval: This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

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Statement of Consent: By completing the following survey you agree to participate in the project entitled Perceptions of science, mathematics, and technology teachers on implementing an interdisciplinary curriculum. **Thank you for participating in the survey!**

Please mark a check in the space provided to the left of the best choice.

1. What discipline do you currently teach?

_____ Mathematics _____ Science _____ Technology

2. Years teaching in current discipline?

_____ 0-5 _____ 6-10 _____ 11-15 _____ 16-20 _____ 20+

3. Years teaching at Independent School District #11?

_____ 0-5 _____ 6-10 _____ 11-15 _____ 16-20 _____ 20+

4. Highest level of education attained?

_____ BA/BS _____ MS/MA _____ PhD/EdD

5. What is your gender?

_____ Female ______ Male

6. What grade level do you teach? (Check all that apply).

7. Which statement **best** describes an interdisciplinary curriculum?

_____ To study a topic and use a variety of applied activities to enhance the learning experience.

_____ To study a topic and integrate math, science, and technology skills to enhance learning.

_____ To study the same central topic in math, science, and technology simultaneously to enhance the learning experience.

_____ Other (please explain):

8. Based on your professional experience, an interdisciplinary curriculum **should include/have**: (Check all that apply).

_____ Exploratory activities

_____ Instruction that is goal oriented

_____ Verbal activities

_____ A broad range of assessment strategies

_____ Hypothesis driven activities

_____ Laboratory instructed activities

_____ Reading activities

_____ Emphasis on problem solving

_____ Cooperative learning

_____ Cognitive strategies

_____ Writing activities

_____ Student Teams

_____ Cross-discipline concepts and themes

_____ Other (please explain):

Read the following statement and circle the best response.

9. Some elements in my curriculum feature an interdisciplinary approach, although they were unplanned.

Strongly Disagree   Disagree   No opinion   Agree   Strongly Agree

10. I purposely incorporate material from other disciplines to prepare students for my curriculum.

Strongly Disagree   Disagree   No opinion   Agree   Strongly Agree

11. An interdisciplinary curriculum would enhance student's learning.

Strongly Disagree   Disagree   No opinion   Agree   Strongly Agree

[Continued on back]

Read the following statement and circle the best response.

12. My professional training prepared me to use an interdisciplinary approach in the classroom.

Strongly Disagree Disagree No opinion Agree Strongly Agree

13. I feel uncomfortable implementing curriculum change in my classroom.

Strongly Disagree Disagree No opinion Agree Strongly Agree

14. I am willing to be trained/re-educated on the basic concepts of an interdisciplinary curriculum.

Strongly Disagree Disagree No opinion Agree Strongly Agree

15. I would find it difficult to work with teachers from other disciplines.

Strongly Disagree Disagree No opinion Agree Strongly Agree

16. Required curriculum, such as graduation standards, make it difficult to implement new ideas.

Strongly Disagree Disagree No opinion Agree Strongly Agree

17. Lack of resources, such as money and time, makes it difficult to implement new approaches.

Strongly Disagree Disagree No opinion Agree Strongly Agree

18. An interdisciplinary curriculum is just another "educational reform" that will not work.

Strongly Disagree Disagree No opinion Agree Strongly Agree

19. Teachers in the other disciplines involved in this survey view my discipline area as less valuable than theirs, and wouldn't be interested in an interdisciplinary approach involving my curriculum area.

Strongly Disagree Disagree No opinion Agree Strongly Agree

20. My curriculum is more important for students than some other disciplines involved in this survey.

Strongly Disagree Disagree No opinion Agree Strongly Agree

21. An interdisciplinary approach would waste valuable class time from my discipline area.

Strongly Disagree Disagree No opinion Agree Strongly Agree

22. An interdisciplinary curriculum would improve upon my current curriculum.

Strongly Disagree Disagree No opinion Agree Strongly Agree

23. An interdisciplinary curriculum would support the learning goals of our high school.

Strongly Disagree Disagree No opinion Agree Strongly Agree

24. My current curriculum emphasizes a holistic learning experience for students

Strongly Disagree Disagree No opinion Agree Strongly Agree

Thank you for participating in the survey!

Appendix B: Survey Reminder

February 23, 2009

Dear [Salutation Here] [Last Name Here],

Last week an invitation was placed in your mailbox, encouraging you to participate in a study regarding your perceptions and attitudes regarding an interdisciplinary curriculum. If you have already returned your completed survey, please accept my sincere thanks. If not, please take the time to answer the questions and return it to me within the next week.

It is extremely important that your opinions are included in my study so all mathematics, science, and technology teachers are represented. If you did not receive the survey or it has been misplaced, please e-mail or call me at ext. 66713 and I will hand deliver a copy immediately.

Thank you once again for your time.

Sincerely,

John Bayer
Blaine Senior High
CEMS Teacher