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IMPROVING RECRUITING AND RETENTION: A STUDY OF MIDDLE SCHOOL STUDENTS ENTERING TECHNOLOGY/ENGINEERNIG PROGRAMS

An Interactive Qualifying Project Report

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by

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Abstract

Enrollment in engineering, especially of females and minorities, has been declining. It is suspected that insufficient skills and interest in mathematics and lack of parental involvement are the cause of this decline. This research project, in collaboration between Worcester Polytechnic Institute and the Worcester Public Schools, makes effective recommendations to Forest Grove Middle School on how they can increase student success and interest in mathematics. Information was gathered from students, parents and teachers to provide both qualitative and quantitative data in the hopes of assessing the influences on the recruitment and retention of middle school students into technology and engineering programs.

Executive Summary

The goal of this project is to determine the influences on the recruiting and retention of middle school students into technology and engineering programs. This goal is important to both the Worcester Public School system, specifically Forest Grove Middle School, and the engineering community as a whole.

Involvement in engineering fields has been on the decline in recent years, and one suggestion to help prevent this personnel shortage is to offer pre-engineering classes at the secondary school level to spark an interest in the subject. It has been found that students are more likely to continue their education in the field of engineering if they are exposed to the subject matter at a early age. To this end, Forest Grove Middle School developed a pre-engineering program for students in the eighth grade. Enrollment in this program, however, continues to be low.

From the findings of previous Interactive Qualifying Project teams working with the Worcester Public Schools, it was determined that poor skill levels and lack of interest in mathematics played a major role in contributing to low enrollment in engineering programs. We therefore chose to focus on studying factors that lead to these problems.

To make effective recommendations to Forest Grove Middle School, it was necessary to find what effects variables such as gender, race/ethnicity, socio-economic status and level of parental involvement have on student interest and success in mathematics. Three populations, teachers, students and parents, have an impact on this problem, and therefore had to be addressed. Several methods were implemented in order to gather data from each of these populations. A survey was designed for students, pre-tested using a class not chosen for our data collection, then revised and administered to

approximately three-fifths of the population of Forest Grove Middle School. A survey was also designed to collect data regarding the attitudes of parents. This survey was pre-tested then administered either at the conclusion of a focus group or over the telephone, depending on parents' availability. Discussion questions were created for a focus group and used to collect suggestions for current and future mathematics programs from parents. All mathematics teachers at Forest Grove Middle School were interviewed using a structured set of questions that were developed and pre-tested to gather and compare information regarding teaching methods and attitudes. The 2001 Massachusetts Comprehensive Assessment System scores for Forest Grove Middle School were analyzed to find if these variables affected student performance on standardized testing.

The data from both surveys was compiled and analyzed using Microsoft Access and Microsoft Excel. This was done to create a database of survey responses that could be used by our sponsoring organization, Forest Grove Middle School, for future analysis. This data was sorted and graphed to provide a visual representation of our results. This allowed for trends to be identified.

The recordings of both teacher interviews and parent focus groups were transcribed. The transcripts were then analyzed by three independent readers to find common themes through content analysis. These data were compared with survey responses from both students and parents to find whether themes were consistent among parent, student and teacher populations.

Existing data from the 2001 Massachusetts Comprehensive Assessment System exams provided by the Massachusetts Department of Education were entered into Microsoft Excel and graphed to find correlations between performance and variables

such as gender, race/ethnicity and socio-economic status. Each multiple-choice item was also reviewed and percentages of students who chose each answer were recorded and compared. Possible reasons for students' choosing incorrect responses were then investigated.

Through analysis of our data, we made recommendations for raising enrollment, especially of females and minorities, in technology and engineering programs. We focused our research specifically on Forest Grove Middle School, allowing us to provide meaningful recommendations to this institution.

We found an overall lack of communication between parents and the school. To improve this communication, we recommended that teachers develop parent guides or manuals containing teaching methods and suggestions for helping students with homework. We also recommended better promotion of current programs through the use of pamphlets highlighting a small number of programs rather than a newsletter containing a long list, many of which may not apply to most students. The last means of improving communication we recommended was more personal notes home detailing a student's performance, whether good or bad, and specifying areas in need of improvement.

By comparing grades and survey responses across the genders, we found a much greater difference in attitudes toward the subject of mathematics than in actual classroom performance. Girls tended to consider mathematics more difficult and to have a more negative opinion of the subject matter. To improve the attitudes of females, we recommended that Forest Grove Middle School provide more opportunities for girls to interact with female role models in engineering fields. This could be done through college mentoring programs or job shadowing opportunities. Programs such as these

would allow middle school girls to interact with females successful in fields involving mathematics and thereby improve their confidence in their mathematics abilities.

Teachers and student survey responses indicated an overall lack of motivation among students in middle ability level classes. Although students at this level possess the ability to perform at the highest level, they generally are not motivated to complete the necessary assignments. One possible way of motivating these students could be through the use of peer/honors tutoring programs where students in higher ability levels from either Forest Grove Middle School itself or Doherty High School would each be matched up with one or more students from the middle ability level for tutoring sessions. Homework groups could also be organized during activity periods or after school for students to work together to complete assignments. These programs may help to encourage middle level students by providing support and guidance.

Through our analysis of standardized testing scores from 2001, we found that students showed poor reading comprehension skills on mathematics questions. This may be due to lack of exposure to mathematics terminology and symbols. In order for students to gain this exposure, vocabulary exercises could be added to tests, quizzes or homework assignments. Word problems, and various ways they can be presented and answered, could also be used to provide practice for open response test items. If students were provided with more practice with these types of exercises, they would be less likely to leave items blank on exams.

The data collected and recommendations made will allow Forest Grove Middle School to improve recruiting and retention of students, especially females and minorities, into technology and engineering programs.

1. Introduction

Since the advent of the computer revolution, technology-based fields have expanded at an astounding rate. The need for workers with a strong background in engineering is ever increasing. Congress' Commission on the Advancement of Women and Minorities in Science, Engineering and Technology (CAWMSET) (2000) points out that the Bureau of Labor Statistics found that "the professional specialty occupations, which include most scientists, engineers and medical workers, are booming, having increased 31.7 percent between 1988 and 1998…[creating] a need to fill 5.3 million new jobs" (page 1).

Two-thirds of the overall U.S. workforce is made up of women, minorities and persons with disabilities, yet 67.9 percent of the Science, Engineering and Technology (SET) workforce in 1999 consisted of white males. Consistently, the smallest percentages of those entering engineering fields have been composed of women (15.4%) and minorities (16.7%). The most severely underrepresented groups are African-American and Hispanic, which together make up only 6.2 percent of the SET workforce (CAWMSET, 2000). One factor leading to this disparity is a societal norm which begins as early as middle school. Society has been conditioned to picture an engineer as a white male, as is seen by the lack of textbook illustrations of women and minorities practicing in the fields of mathematics and science (Clewell, Anderson & Thorpe, 1992). A national effort must be made to instill the value of engineering in young people making career choices, especially females and minorities, and those who influence these choices, specifically parents and teachers. These problems are prevalent not only in Worcester, but across the country as well.

The student body of the Pre-Engineering program at Doherty High School is currently composed of approximately 90 students, yet only 30 percent are females and less than 10 percent are minorities. This is not nearly representative of Doherty's overall population, which is composed of approximately equal numbers of students of each gender and nearly 60 percent minorities (Camoreyt, 2002). The major issues with recruiting and retaining students, especially women and minorities, into these programs are lack of parental involvement, poor skill levels and lack of interest in mathematics (Labrecque, Pistorino and Dolan, 2001). These problems begin at the middle school level, and therefore must be investigated there.

In the past two years, Forest Grove Middle School has implemented a new technology program for students who are interested in engineering fields. Enrollment, in this program however, continues to be low. For example, last year only 50 students of the over one thousand eighth graders in the city of Worcester enrolled in the technology cluster at Forest Grove Middle School. Students from this program ideally continue into the Pre-Engineering program at Doherty High School. This leads one to wonder what action Forest Grove Middle School can take in order to increase student success and interest in mathematics. How can "math fear" be reduced and math skills improved? How can we influence parents and students about the need for success in high-level mathematics classes?

The goal of this project is to determine the influences on the recruiting and retention of middle school students into technology and engineering programs. We focused on studying factors that lead to poor skill levels and loss of interest in

mathematics. This information was used to make recommendations on how Forest Grove Middle School can raise interest and promote success in mathematics.

Mr. Donald Kelley, principal of Forest Grove Middle School, has worked in education for thirty-one years and recognized the significance of this project to the future of his students. Our work will aid Mr. Kelley and his faculty in their efforts to improve student interest and success in mathematics. In particular, we will outline the strengths and weaknesses of specific groups of students and represent these in chart form. These charts can be used by the faculty to enrich the curriculum, focusing on the identified weaknesses.

The following chapters will outline our approach to studying the problems of poor mathematics skills and interest. The background and literature review section shows that past research places great emphasis on parental involvement and gender and ethnic differences in learning styles. This research has led us to develop a set of research questions and a plan to further investigate the driving factors behind low enrollment in pre-engineering programs. This plan will be described in detail in the methodology section. The data analysis section contains the results of our methods and gives the information necessary to answer our research questions. These answers will allow us to make larger conclusions and recommendations for improving mathematics skills and interest, which can be found in the conclusions section.

2. Literature Review

2.1 History and Background

In December 2000, the Massachusetts Department of Education (MDOE) began requiring Engineering in the public school curricula (Miaoulis, 2000). In response to these new curriculum frameworks (http://www.doe.mass.edu/frameworks/), the Worcester Public Schools developed a pre-engineering curriculum for implementation citywide. In October 2001, a team of WPI students reviewed this curriculum with a focus on women and minorities. The students, Labrecque, Pistorino and Dolan (2001), produced a report that made recommendations for improving enrollment among minorities and females, in the pre-engineering program at Doherty High School. Pre-requisites for entry into the pre-engineering program at Doherty High School are Algebra and an 88 percent grade point average. As the report shows, skills and interest in math and science subjects needed to be improved in order to increase enrollment in the pre-engineering program (Labrecque et al., 2001). This improvement was also necessary in order to access the new political and economic institutions, as well as relationships, that are evolving from the computer revolution, which is forcing people to master the tools of mathematics and science. The demand for this mastery is greater than ever, and the role that mathematics plays will most definitely increase in the future. Therefore, it is essential that children are equipped with the ability to meet these demands, *now*. It was the goal of this study to cover past research and help make recommendations for a study on future improvements to mathematics skills at Forest Grove Middle School.

A student's progress in mathematics can often be hindered by low expectations of his/her superiors, in this case parents and teachers (Anderson, 1990). Often if a student is

not expected to produce, or is presumed incapable, he/she will not put forth effort. The experience of repeated failure will eventually overcome the student and reduce his/her self-confidence and esteem, increasing the likelihood that he/she will never try or even drop out of school altogether. Slow learners, minorities, and females are groups of students that are at risk for having lower perceptions of their mathematical abilities. As stated by Catsambis (1994), "[F]or middle school students, gender differences in performance and course work are minimal, but strong differences exist in attitudes and perceptions of the usefulness of mathematics" (p. 200).

Forest Grove Middle School (FGMS) is in the Doherty Quadrant of Worcester, which makes it the main feeder-school for Doherty High School (DHS). This quadrant includes a wide variety of socioeconomic backgrounds ranging from the needy to the affluent. The school has approximately 900 seventh and eighth grade students. Of these students, about 48 percent are defined by the school as minorities, meaning that they fall into ethnicity categories other than White, including American Indian, Asian or Pacific Islander, Hispanic-non-white, Hispanic-white or Black. The majority of these students are of Hispanic origin. Asians and Blacks form the smallest portion of the student body. The school's diversity is not well represented in the faculty, for only approximately 15 percent of the teachers are minorities. The female to male student ratio is essentially one to one.

The mathematics curriculum includes three levels of mathematics: an honors level, a college level, and a standard level. Students in the honors track generally continue into higher level mathematics in high school, as they are the only students currently offered Algebra at the middle school level (Kelley, 2002). Intermediate level

students are also able to enter the Pre-Engineering track at DHS if they are able to meet the pre-requisites of Algebra and an 88 percent average (Camoreyt, 2002).

Forest Grove Middle School is separated into four "clusters" per grade. A cluster is made up of about 125 students, who take classes in English/Language Arts, Mathematics, Science, and Social Studies from a set of four teachers. Students are assigned to clusters randomly in the seventh grade. They are then given the choice to enter the Technology/Engineering cluster in the eighth grade. Currently, only two eighth grade clusters are able to offer Algebra, with the other two offering Pre-algebra as their highest mathematics class.

2.2 Student Interest and Success in Mathematics

A strong understanding of mathematical concepts is necessary to access new political and economic institutions and those without the required tools are losing access fast (Silva et al., 1990). With the complexity and detail that technology relies on mathematics, it is essential, and will be more so in the future, for a firm grasp and understanding of the underlying mathematical concepts and the many relationships that they have with other subjects. Students who do not acquire a sufficient background in mathematics prior to college are virtually eliminated from a number of careers ranging from those in physical sciences and engineering to social sciences and psychology. It has been reported that those who take more mathematics in high school and /or in college earn a substantially larger income in the first decade of their careers (Anderson, 1990). Data shows that the pursuit of a more rigorous high school curriculum, which improves chances that a student will elect a math-related major in college, is correlated to a high ability level in middle school. Moreover, proficiency in math also shows a higher rate of

success and income potential, generally. Thus it is necessary to successfully assign middle school students to the highest mathematics ability level possible (Catsambis, 1994).

A mathematics program is successful at the elementary school level if the children develop an understanding of basic mathematical ideas and appreciate the role of math in daily life. In order for the program to be successful, it has to adapt to the interests, aptitude, and maturity level of the students (Grossnickel, 1968). Children need to not only understand various mathematical concepts, but also be able to apply them to a wide range of unpredictable problems. This requires that the middle school's math program be rich, invigorating, and well integrated, which can be achieved through creating interest among the students, stimulating teaching methods, and parental, as well as community, involvement (Grossnickel, 1968).

In order to generate interest, teachers, parents, and administrators need to establish and reinforce expectations. The parents and communities should set the expectation that minority students can and should perform well in mathematics (Anderson, 1990). Toliver (1993), a teacher at East Harlem Tech in New York City, contributes part of the success of her program to the fact that she sets high expectations for her students. She believes "every student can succeed in mathematics, even if they have never before been successful" (p. 37). At the beginning of the year, she tells the students, "[F]orget what has happened in the past. This is a new day and we will work from here." (p. 38) As well as encouraging a teacher to let his/her students know that he/she is willing to go every step of the way to teach, Toliver also says to tell the students that they must do the same to learn.

One-way to positively affect student attitudes and perceptions of mathematics is to create interest in the subject. There are many different ideas on how this might be accomplished. Toliver (1993) suggests creating interest by not following traditional teaching methods. She prepares her own lessons without following a textbook, which enables her to mix things up a bit. She also gets attention from her students with costumes and laughter. However, her goal is not to entertain them, she uses the attention to engage in conversation, and idea and question sharing (Toliver, 1993).

There are many other ways to create interest among students and various resources exist to assist teachers. In Lower Township Elementary School in Cape May County, New Jersey, a Math Month was created to promote and activate creative thinking about the need to focus on and upgrade mathematics instruction. Part of the effort was to refocus attention on the wealth of information accessible to teachers concerning mathematics innovations (Szemcsak, 1996). A separate effort at Martin Luther King, Jr. Middle School in Cambridge, Massachusetts involved a program called "The Algebra Project." This program also focused on the resources teachers utilize in their classrooms. It sought to challenge the way mathematics teachers construct their learning environments by producing teachers who are able to facilitate a mathematics learning environment grounded in real life experiences and to support students in the social construction of mathematics (Silva et al., 1990).

2.2.1 Expressions in Other Aspects of Life

One key strategy in creating interest is to use abstract mathematics to analyze concrete problems. Students might participate in frequent discussions that engage them in the twin process of creating mathematics and integrating their mathematics with the

physical world. It also helps them to learn through their own experience about the social construction of knowledge. For example, discussions might include talking about a familiar physical event in which they ask and answer obvious questions, such as how many cafeteria tables are needed to accommodate the students at lunch (Silva et al., 1990). Toliver (1993) encourages these discussions by sending students out on a journey to discover how math is used in everyday life. For example, she might have her students go to the schoolyard, and see how many square feet are in the playground, if it is so many feet long and so many yards wide. Interactions of this type allow the exploration of math situations, relationships, and possibilities in the environment. Opportunities to witness mathematical concepts exist in all areas of living. Therefore, student experiences should be relevant to many different areas in the student curriculum (Grossnickel, 1968). Picker (1992), a teacher in a New York City remedial math class, incorporates interdisciplinary discussions about real-world situations showing how math is related to other subjects like chemistry and law. It is important that students see how math is related to other issues like history, language, literature, and the "real world." Math is critical throughout daily life, from paying bills to creating a time schedule.

2.2.2 Oral Communication of Mathematical Concepts

It often helps students to relate math to their daily lives through these discussions as well as oral projects. The Algebra Project is a supporter of these types of projects. Teachers use such regimented English sentences to lead students from their intuitive language responses into equations that represent physical events. Through these activities, teachers can demystify mathematics, demonstrating to students that the language of math is like all other language: it can communicate characteristics about

physical events that are part of their everyday experience (Silva et al., 1990). Grossnickel et al. (1968) point out additional positive effects of oral work, it gives attention to small details in understanding concepts, such that a decimal number signifies fractions of a real number. It also helps to review and practice. Having students orally explain solutions to math problems results in students developing the ability to verbalize abstract ideas (Toliver, 1993).

Math projects and math fairs are another way to create interests. Students can do more in-depth research about mathematical concepts while at the same time being involved in different topics related to their daily lives. Activities designed to implement these kinds of projects exist as part of Math Month at Lower Township Elementary School in Cape May Town, New Jersey (Szemcsak, 1996). Math fairs at East Harlem Tech work well to provide students the opportunity to showcase their projects to parents, teachers, and other students in the community, thus creating a sense of pride and continued interest (Toliver, 1993).

In choosing discussions, oral projects, journeys, and other various experiences, a set of criteria exists that should be fulfilled in order to ensure a positive contribution to the main goal of a successful math program. One principle to follow in selecting and planning a math experience is that the number, measurement, and form of the experience on every grade level are appropriate in terms so that the individual needs, abilities, and interest of each child can be met. This is because every child has their own rate and way of learning and growing, even if certain characteristics might be anticipated and expected of a certain age group or grade level (Grossnickel et al., 1968).

2.2.3 Learning Styles

In order to effectively meet the individual needs, abilities, and interests, several questions should be asked about the resources. Such questions are as follows: Does the variety and quantity of resources in the classroom allow children the option of different choices? Are resources organized so they that they are quickly accessible? Does variety in the resources to account for different learning styles, such as those who learn by handling concrete or abstract material? Do resources allow the teachers to have time to assist those that need extra help or extra challenge? And, do the resources provide a multi-sensory approach to knowledge? The answers to questions like these help determine what resources should be used to benefit each child in the class (Grossnickel et al., 1968).

Some suggestions given for resources are exploratory materials, like building blocks, abacus, and rulers, that students can handle and move in order to grasp concepts. Illustrations and pictures are recommended, like graphs, maps, diagrams, newspapers, magazines. To help arouse and maintain interest, motion pictures and television are suggested. Textbooks can be used for a program guide, with workbooks for practice. It is often a good idea to incorporate other textbooks by using materials from college and graduate-level texts once students' interest and understanding have increased (Picker, 1992). Pencil, paper and chalkboards can help clarify situations, problems, or relationships. Bulletin boards and displays can stimulate interests and cover various topics (Grossnickel et al., 1968).

Resources must also be selected to account for the various rates at which students learn. They must be utilized in a way that reaches students with slow understanding as

well as advanced. The following list some ways to adapt the curriculum for slow learners:

- Make greater use of concrete social situations to give meaning to operations.
- Let the students work with concrete materials and resources by using graphs and tables.
- Use a variety of visual aids to enable learner to visualize situation.
- Encourage them to invent procedures that might be meaningful to them.
- Introduce new difficult topics slowly, giving them the chance to generalize
- Do not introduce new topics unless students clearly understand.
- Try not to assign problems that will be too challenging and thus, frustrating them.
- Give extra guidance in directed reading activities.

For reaching superior learners, the following lists some suggestions:

- Provide programs for them to complete work in shorter time periods, and present new material faster.
- Add new learning experiences by asking for a wider and deeper understanding of concepts.
- Motivate them with honor rolls, math clubs and contests, by reporting unusual achievements, and making available extra resources to add interests
- Textbooks should contain fewer illustrations with material and reading that is more difficult.
- Avoid overuse of visual aids, as they might not be as worthwhile (Grossnickel et al., 1968).

2.2.4 Role Models

It is also effective to stimulate interest through guest speakers. The Algebra Project was successful with this when they invited volunteer speakers from the neighborhood that spoke of the importance of math in their lives (Szemcsak, 1996).

Anderson (1990) states that black children tend to pattern themselves after the Michael Jordans and the Magic Johnsons who have achieved great heights. Therefore, role models can play a crucial role in interesting students. At DHS, students involved in tutoring the middle school students can act as role models in engineering, especially for females and minorities and those students without parental involvement (Labrecque et al., 2001).

2.2.5 Linking Math to the Real World

While role models can stimulate interest, as well as educate the children about various opportunities, it is the parents and teachers who were found to be the most influential forces on career/major choices of female college students in engineering (Labrecque et al, 2001). This highlights the importance of parents and teachers supportive of engineering careers for women. Children often feel like they are better suited to medicine because they want to help people. Often times parents who are not sure what engineering is will push intelligent children toward medicine. The society-based aspects of engineering need to be stressed in educational materials and parents need to be educated about the possibilities in engineering and mathematics (Labrecque et al., 2001).

One way to educate the parents and accomplish the goals is through a joint venture between parents and teachers. The Math Month project, of Lower Township Elementary School in Cape May County, is an example of this type of joint venture. The project stresses ongoing teacher training, follow up, networking, and support in order to nurture support among parents, community organizations and the broader community. An example of how this is done is to make all parents aware of new mathematics

recommendations for instruction coming from the National Council of Teachers of Mathematics. Teachers also set up a bi-weekly newsletter called the *Math Madness*, which is sent home with each child every Tuesday and Thursday. It provides parents with the news of school mathematics activities, mind-bending puzzles, and suggestions on how to help their children with schoolwork at home. To insure that parents were getting the newsletter, a family activity page was included to be returned to the school. They also incorporated parents into the learning process by organizing a family Math night where parents and children could learn together by playing games and doing math-related activities (Szemcsak, 1996).

2.2.6 Evaluation

Once attempts to utilize these various methods have been made, it is necessary to perform some type of evaluation of the program. Was the program successful or not? Does the child understand the basic mathematical ideas and appreciate the role of math in daily life? Some ways to tell are through standard tests and objective test procedures. However, because a typical student is not the "standard" student, these standard tests and objective test procedures are not always best (Silva et al., 1990). Less formal procedures such as, inventories and questionnaires about attitudes, interests, activities, and methods of study, interviews, conferences, and personal and oral reports are other ways to evaluate performance (Grossnickel et al., 1968).

The Algebra Project does not rely on traditional paper and pencil tests. Rather, teachers are asked to use portfolios of students' work, records of students' performance on workstation tasks, and other tools to assess their students' progress toward achieving the curriculum learning objectives (Silva et al., 1990). Toliver's (1993) math program

evaluates performance through the quality of assignments, how much effort and thinking do they put into the work. She does not grade them on how they perform on a test, like 9 out of 10 correct. She feels this standardized method does not encourage participation as her method does.

How can one tell though, if the appraisal method accurately measures a child's understanding? The following lists some guidelines to follow in answering this question:

- Does the method measure the characteristic or aspect of growth that you want to know about?
- Does it really measure what it says it measure, and not something else?
- Is the method reliable or accurate?
- Is the test easy to administer and are its instructions easy to follow?
- Do the tests provide results that can be easily understood and compared? (Grossnickel et al.,1968).

If accurate evaluation methods have been used and the student has been shown successful, the process to implementing a successful math program is not over. Because demands change with time, this process is iterative. The question of what makes a successful program must be asked again and again. Different steps might need to be taken and new methods and resources utilized to meet the objectives for a successful program.

2.3 Parental Involvement

A student's success in mathematics does not depend solely on the educational system. Parents play a key role in their child's success in mathematics. What better place for a child to look for encouragement than in their own home? It is important for parents to communicate with their children as well as the faculty of the schools,

especially the teachers of their children. The parent-teacher relationship is just as important as the parent-child relationship. It is most beneficial when parents actively participate in school affairs, such as curriculum changes, programs, and activities.

2.3.1 Positive Parental Conversations

It is necessary for parents to get involved with their children's activities. Parents must talk to their children in order to gain insight into what is happening in their lives. They should ask themselves, "[T]o what degree do they have conversations directly related to education" with their children (Hallinan & Sorensen, 1987). These conversations can have direct and indirect influences on children. They may indirectly keep students interested in mathematics, but more importantly they encourage them to stay committed to success. The content of the conversation has to be carefully prepared. When children approach their parents and tell them that they are having trouble with mathematics, some parents tend to downplay the seriousness of the situation by saying they too had trouble in mathematics when they were in school (Kelley, 2002). Such rationalization may cause a child to lose interest in mathematics. Thus it is important for parents to watch what they say to their children. Parents should inform their children of how wonderful it can be to excel in mathematics. This type of encouragement provides necessary motivation for the children.

2.3.2 Reasons for Lack of Parental Involvement

As for the parents that do not involve themselves with their child's activities, they have their own rationale, whether the reasons are ideological or factual. Students that are in middle school differ from elementary school because they are developing a sense of autonomy and often do not want their parents at school (Catsambis, 1994). On the other

hand, parents may think that their children are old enough at this stage to take care of themselves. Studies have shown that parental involvement tends to decrease at the middle school levels. Parents do not know how to stay involved while still allowing their child freedom to develop independently (Beghetto, 2001). Parents should not hold their pessimistic attitudes regarding schooling in correlation to their own educational experiences. "Parents who have dropped out of school do not feel confident in school settings" (Finders & Lewis, 1994). Economic constraints often do not allow parents to attend school meetings. If a family cannot afford childcare, then parents must stay home with their children and are often not able to leave the house. Cultural differences can also be an influential factor that reduces parental involvement. For example, in some cultures, independence is considered essential for success. Parents may believe that their children do not benefit from their presence at school (Finders & Lewis, 1994).

2.3.3 Communication between Parents and Teachers

In order to get parents involved with their child's education, it is necessary to establish communication between the teachers and the parents. The underlying question in this case is how to get through to the parents. Today there are a variety of new methods to improve parental participation. Many of the new methods were developed as a result of technology. To get parents involved, teachers should take the initiative to make first contact with the parents, by simply contacting them on the phone (Ramirez, 2001). They should schedule meetings that are convenient for the parents. For a culturally diverse community it may be necessary to establish bilingual hotlines in order to alleviate the problem of a language barrier. One particular example is online

communication using the Internet. The introduction of a virtual community has its advantages as well as its disadvantages. Some of the advantages are:

1. Parents can access information and discussions on their own time. This overcomes the time constraints of parents with demanding jobs and families.
2. Parents are able to plan and compose messages carefully to voice concerns. This eliminates the sometimes-strained situation of parent-teacher meetings.
3. Schools can track recurring concerns and address them at planning meetings.
4. Newcomers to the community can easily acquire background information on the school system and to find out where they can best contribute to past concerns.
5. Online communications can be documented and archived to act as a supplement to traditional means of contact such as phone and letters sent home. This helps eliminate the problem of correspondence not reaching parents.
6. Provides a forum for dialog between parents and schools. Communication lines are opened (Beghetto, 2001).

The disadvantages include:

1. Not every family owns a computer, although libraries and local businesses can be brought in as education partners in a lending/donation program to allow these families access to the discussion boards.
2. Virtual communication cannot replace more traditional forms of communication. Comments are easily taken out of context-this is less likely in personal contact. The discussion board is not meant to replace traditional communication, but to serve as a supplement. Schools must still offer a variety of opportunities for involvement (Beghetto, 2001).

Teachers have to be careful when using a virtual community. They cannot assume that all parents have access to this technology. Schools can improve this procedure by making computer labs open to the public. It is also necessary to be aware that parents may be resistant, uncomfortable, or unable to use such technology. As a result it may be necessary for the school to provide tutorial programs.

2.4 Gender and Racial/Ethnic Differences in Approaches to Mathematics

Many past studies have focused on the differing approaches of females and males to mathematics in the hopes of explaining the serious under-representation of women in engineering fields. Viswanath and Morris (2000), for example, found that males and females stress entirely different evaluation criteria in their decisions about a technology. Research findings such as these can be applied to mathematical principles, and may help reveal reasons for the general underachievement of women in mathematics. It has been suggested that other factors, such as lack of role models, may account for the small percentage of minorities pursuing advanced mathematics (Catsambis, 1994).

2.4.1 Effects of Socialization

Middle school is generally the time period when gender differences in mathematics perception become more pronounced. With the new learning environment of the middle grades, students are exposed to larger numbers of male teachers. This is also the time when classes are often separated into ability levels, causing more competition between students (Catsambis, 1994). Females are more likely to develop high levels of performance anxiety than males, possibly due to the messages they receive during early socialization. Girls are frequently taught that they will not need math in their future careers (Felson & Trudeau, 1991). Female students are thought to internalize a societal message that science and math are unfeminine activities (Clewell, Anderson & Thorpe, 1992).

Minorities are also victims of negative socialization regarding mathematics. They are often exposed to stereotypes that mathematics and science are white male activities. Parents and peers of minorities also tend to discourage mathematics activities, especially

extra-curricular programs that could help them enter advanced math classes (Clewell et al., 1992). A past study also found that minority students at Forest Grove Middle School feared they would not be able to cope with being the only person of their race/ethnicity in an advanced class (Labrecque, Pistorino & Dolan, 2001). This is especially prevalent in the role models they see in middle school, as typically only ten percent of teachers are minorities, and very few of these are in the fields of mathematics and science (Kelley, 2002).

One study found that parents of girls thought that mathematics was more difficult for their child than did parents of boys, even among groups of parents whose children performed equally well (Felson & Trudeau, 1991). It also found that girls were more likely to describe mathematics as difficult than boys of the same ability level. Another study agreed, stating that at the middle school levels, females develop a "poor self-concept as a doer of math or science" (Clewell et al., 1992, p. 46). Many times, even by the ninth grade, girls have chosen careers that they feel will not require advanced mathematics. These varying perceptions of mathematics subject matter can lead to girls failure to enroll in high-level math electives in high school (Catsambis, 1994).

2.4.2 Varying Technology Acceptance

Viswanath and Morris (2000) point out that major gender differences also emerge in the standards men and women use to evaluate a new technology. They studied the affects of gender-specific perceptions on technology acceptance. Men place a higher emphasis on the perceived usefulness of a technology, that is, whether or not it will help them in daily tasks. Women, on the other hand, are most strongly influenced by the perceived ease of use of the same technology. This indicates that women will tend to

reject learning a technology, in this case mathematics, that they consider difficult. Subjective norm, whether or not an individual feels peers and superiors would like them to perform a specific behavior, also weighs more heavily on the decisions of women to accept or reject a new technology. Similar results came from a study performed by Gefen (1997), who used e-mail as the experimental technology. These psychological concepts, when applied to mathematics, indicate a greater need for encouragement in female students than in males.

2.4.3 Different Means of Communication

Communication between teachers and students is very important in the learning process. McNeal (2001) attributes communication problems to the fact that women and men have been found to use language, particularly regarding technical subjects, in very different ways. He believes male teachers communicate better with male students, and due to higher percentages of male teachers beginning at the middle school levels, especially in math and science, this may cause girls to come in with a disadvantage. This communication difference also carries over onto language used on exams and homework problems. If female students are not as able to understand the questions being asked, they are less likely to perform well on assessments (McNeal, 2001).

Various teaching styles and curricula also tend to favor one gender over the other. Miller, Mitchell and Ausdall (1994) found that a focus on independent, competitive work favors the most common male learning style, while a focus on network oriented activities or application of rules tends to favor a predominantly female learning style. Timed tests such as standardized testing have been found to particularly favor male learning styles. Society conditions females to follow rules more closely, and therefore have a higher level

of anxiety regarding estimation or guessing on timed evaluations. Males are more likely to guess solutions when time runs short or difficulty arises (Miller et al., 1994). Male students have also been shown to be more inclined to attempt unfamiliar problems than female students. This hinders the progress of female students on novel tasks often seen on standardized tests (Felson and Trudeau, 1991). In studies, the same female students greatly improved their achievement on comparable questions when told to take as much time as they needed, as females are more inclined to use complicated algorithms and prefer deliberate and cautious problem solving (Catsambis, 1994).

2.4.4 Knowledge of Opportunities

Limited knowledge of opportunities and careers have also been found to hinder female and minority student progress in mathematics. Females and minorities tend to be unaware of mathematical aspects of professions such as medicine and education (Clewell et al., 1992). There is also a relatively low number of pictures representing females and minorities in science and mathematics textbooks commonly used in middle level classes. Female and minority students at FGMS have shown interest in activities such as "Building a Robot" on surveys. These same students, however, later indicated that they did not feel that engineering would help them to get a job they would like (Labrecque et al., 2001).

At FGMS, past research indicates that the general information provided by educational studies holds true. Three classes (approximately ninety students) were surveyed at the school and it was found that females based many of their attitudes about math on anxiety and self-esteem issues (Labrecque et al., 2001). Females and minorities rated themselves as not likely to be able to cope with peers and teachers treating them

differently in a more advanced mathematics or science class. These same groups listed doctor, nurse and teacher as the career types that interested them most, above careers such as scientist, engineer and lawyer. The choice of those that were labeled the "helping careers," show that females and minorities tended to base career choice on the ultimate outcome: helping people. On another survey question, female students most often disagreed with the statement "Engineering skills will allow me to better society," indicating that these students are not aware of the society-based nature of engineering projects (Labrecque et al., 2001).

From this past research, it is evident that the relationships between gender, racial/ethnic background and level of parental involvement to student success in mathematics must be investigated at Forest Grove Middle School. This project will study the factors influencing student interest and success in mathematics, such as class levels and the attitudes of parents and teachers. The methods by which these variables will be analyzed will be described in the following section on methodology.

2.5 Summary

Past research has shown that parental involvement and varying approaches to mathematics are major influences on student interest in success in this subject. Communication is necessary to improve skill and interest among all students, particularly females and minorities. Schools must work with parents to develop programs that are accessible and appealing for all groups, as no one can afford to be left behind in the movement toward a more technology-based society. To this end, we developed a strategy for investigating the influences on student interest and success in mathematics at Forest Grove Middle School.

We used student surveys to gain quantitative data on the relationship of student interest and success to variables such as gender, racial/ethnic background and current class level. Parents were invited to participate in focus groups that were used to gain both quantitative and qualitative data on the reasons behind lack of parental involvement in a child's education. We also interviewed mathematics teachers at FGMS to find possible correlations between teaching methods and student success. These methods will be described in detail in the following methodology chapter.

3. Methodology

The IQP conducted in B-term of 2001 found that the lack of parental involvement, poor skill levels and lack of interest in mathematics led to low enrollment, especially of females and minorities, in pre-engineering programs. In order to raise this enrollment, it is necessary to improve mathematics interest and skill, especially among females and minorities, at Forest Grove Middle School. Accomplishing this goal involved the study of three main areas. First, we investigated how parental involvement, gender, racial/ethnic background, and class level effect student interest/success in mathematics. Second, we collected parental feedback on current programs and suggestions for involving them in future programs. Lastly, we studied the impact of teacher attitudes and practices on student interest/success.

3.1 Research Design

We used both quantitative and qualitative methods to study the influences on the recruiting and retention of students into technology/engineering programs. We set out to study students in the seventh and eighth grade at Forest Grove Middle School in Worcester, Massachusetts. We applied the variables of gender, socio-economic status, racial/ethnic background, level of parental involvement, teaching methods, and student interest and success to this population.

The rest of this chapter serves to identify the methods that we used as well as the associated data collection procedures. In section 3.2, explanations for choosing the methods and descriptions of how these methods were used are given. Descriptions of the equipment, tools, and materials needed are given in section 3.3. The data collection strategies are also described in this section.

3.2 Method Identification

In order to meet our objectives, we implemented four methods: student surveys, parent focus groups, teacher interviews, and analysis of existing data from the Massachusetts Comprehensive Assessment System (MCAS). Student surveys were the main source of information regarding the effects of variables such as gender, racial/ethnic background, and class level on student interest/success in mathematics. Parent focus groups gave us insight on factors that may cause a parent not to get involved in his/her child's education. Teacher interviews provided information on teaching methods and the success their students have.

3.2.1 Student Surveys

Seventh and eighth grade math students were our main source of information. It was necessary for us to find what draws them to mathematics and what accounts for their success. We also investigated the various levels of parental involvement among students at FGMS. Focus groups were not a reasonable method for gathering this data, as the questions we asked the students, especially regarding their family backgrounds, were fairly personal. The fact that students at the middle school level are also quite strongly influenced by the opinions of their peers again made focus groups impractical (Blaisdell, 2002). We feared students at this age would tend to be intimidated by a face-to-face interview with one or more college students, so we ruled out this option as well. Although archival data was available for test results and past mathematics performance, it did not contain information about parental involvement or specific interests of the students, making it a poor resource for the information required. Taking each of these

factors into consideration, we chose to administer an approximately ten-minute-long survey to students, ideally during their math classes.

In order to survey students at the middle school level, a parent's consent is required. To satisfy this requirement, a letter was included with the school's monthly newsletter. The newsletter, called "Middle Years", contains suggested activities for parents to do with their children at home. General school information is often attached to the newsletter. Our letter explained to parents our project goals and the process we would use to accomplish them. We notified them of our plan to give a survey and let them know that they may receive a follow up letter or phone call regarding our focus groups. A tear away portion was included to allow parents the opportunity to exclude their child from our survey, should they object to the contents of the survey. See Appendix A for a copy of the letter. Normally students would be asked to sign up for surveys, but due to constraints on resources and time, teachers volunteered whole classes at once.

The survey was pre-tested using students from one class in which the teacher taught three at the same ability level. The pre-tested class was made up of 23 students at the college level. We used what we called a "duplicate class," a second class taught by the same teacher at the same ability level, for the pre-testing, assuming that a teacher would teach two classes of the same ability level in the same way. We surveyed students from one math class at each level in each of the seventh and eighth grade clusters except for the engineering cluster where we surveyed all four classes, as they were all learning different material. This resulted in a total of twenty-four classes to be surveyed, as one teacher only had two ability levels and another had four. This gave us data from

approximately three fifths of the student population of Forest Grove with an average of sixty-five students from each teacher.

3.2.2 Parent Focus Groups

Parents are a major factor in determining the students' interest and success in mathematics. With this in mind, it was important to include in gathering information for this study. Contacting parents can often be difficult, as messages do not reach parents through their children (Kelley, 2002). Surveys sent home might not have been returned and would have been very time consuming. The best way to gain parental feedback on current programs and suggestions for involving them in future programs is with focus groups (Blaisdell, 2002). Meeting the parents gave the study an important understanding of the background of the students. It was important to make sure that this focus group was confidential, because parents may fear to be embarrassed, thus causing them to lie in their responses.

3.2.3 Teacher Interviews

Teacher attitudes and practices are a major factor in determining students' interest and success in mathematics. It was then necessary to include the analysis of their attitudes and practices in order to reach our project goal. The most appropriate way to retain data on their attitudes and practices was with interviews. Interviewing the teachers provided us with a deeper understanding of exactly how the teachers at Forest Grove can impact the students' interest and success, especially the female and minority students. All 7^{th} and 8^{th} grade math teachers were interviewed, resulting in eight interviews. We interviewed all eight teachers as we were surveying students from each of their classes. Also, the more teachers that were interviewed, the more trends relating practices and

attitudes to student interest and success could be noticed and accounted for. Interviews were also kept confidential in order to promote honest answers.

3.2.4 Analysis of MCAS Data

Each year, after the MCAS tests have been graded, the Massachusetts Department of Education provides a detailed breakdown of the scores in each subject. This breakdown provides specific information about each question such as what subject area it was designed to test (number sense, statistics and probability, etc.), and the format of the question (multiple choice, short answer or open response). It also gives information regarding the average scores of students of each racial/ethnic background and gender. Average scores for the students at Forest Grove are listed alongside averages for the district of Worcester and the entire state of Massachusetts. We focused on the details of the mathematics section of the test given to students in the eighth grade at Forest Grove in 2001. This data was carefully analyzed to determine whether any correlations exist between either demographic information (gender or race/ethnicity) or specific type of question and whether or not a correct response was given. This helped to identify strengths and weaknesses of all students at Forest Grove and allowed for better recommendations for future programs.

3.3 Data Collection Procedures

3.3.1 Student Surveys

The surveys were administered to students during their mathematics classes. This provided a comfortable setting and promote honest answers. Students were asked to anonymously answer a series of questions on their gender, race/ethnicity, socio-economic background, current class level, interest in and attitudes toward mathematics. The survey

can be seen in Appendix B. The length of the survey was held to no more than fifteen minutes.

Special Strategies:

In order to promote honesty and cooperation, incentives were offered for students who completed the survey appropriately. A variety of candy was offered and was distributed with teacher permission at the completion of the survey.

3.3.2 Parent Focus Groups

We planned to conduct three focus groups with approximately ten respondents in each. Due to lack of response from parents of students not currently enrolled in the technology cluster, we were forced to cancel our second focus group, leaving us with only two. One of these groups consisted of parents of students who were currently enrolled in the technology cluster. The parents that were invited to this group were randomly selected by choosing every 8th parent from an alphabetical list of all students in the technology cluster. The parents chosen from this list were contacted by phone. The other group consisted of parents of students that are not currently enrolled in the technology cluster. Those invited to this groups were randomly selected by choosing every 4th parent from an alphabetical list of the rest of the student population. A letter (Appendix C) was sent home via mail offering two focus group sessions. Parents agreed to participate by returning the lower portion of the invitation to their child's math teacher. One day before the focus groups began, a follow-up call was placed to each respondent to confirm his/her attendance.. On the day of the group, a reminder card (Appendix D) with specific driving directions and a map was sent home with the student.

For convenience, the focus groups were held at 6:30 PM. Groups were held in the Taylor and Chairman's Rooms of the Campus Center on the Worcester Polytechnic Institute (WPI) campus to ensure a neutral setting. The methodology for having focus groups with the parents was as follows:

1. We implemented an icebreaker to make the parents feel more comfortable.
2. Participants were asked to write down their initial reactions to mathematics programs at FGMS.
3. We asked the parents for some suggestions on how to help the students succeed in mathematics. This allowed parents to bounce ideas off one another.
4. We ask the parents if they had any criticism on the current teaching methods and programs.
5. The parents completed a post survey (Appendix E) in order to gain demographic information. At the end of the survey, parents were asked to rank suggestions made during the group discussion according to whether they would be willing to participate.
6. The focus groups lasted about an hour.

Special Strategies:

In order to get the parents to come to the focus group, we raffled off a $25 gift certificate to a local supermarket, Santiago's Market. Refreshments and snacks were also provided. At the end of the week following all focus groups, participants were mailed a thank you letter announcing the winner of the gift certificate and offering an opportunity to view the results of the group discussions (See Appendix F).*

* Due to unforeseen circumstances, this methodology was amended. See Section 4.2 for changes made.

3.3.3 Teacher Interviews

The eight interviews were conducted at the school. Interviews were held in each teacher's classroom, as they were most comfortable and confident in this setting. This way the teachers were more likely to answer our questions honestly (Blaisdell, 2002). Requests for interviews were made at the mathematics department meeting. The interviews were held whenever was most convenient for the teacher, either during the school day during their break period or after school. The interviews lasted 30 minutes to an hour. In this time allotment, we requested information such as the success level of students, demographics of students in each class, various teaching styles and methods of motivation that the teacher employs, and recommendations for creating student interest that he/she might have. Teachers received thank-you notes for their participation in and support of our study. The interview questions can be seen in Appendix G.

3.3.4 Analysis of MCAS Data

All data used for analysis came from the mathematics breakdown packets provided to us by Principal Donald Kelley. These were made up of the mathematics sections of the breakdown for FGMS distributed by the Massachusetts Department of Education. Included in these packets was information regarding averages for the school, school district, and state.

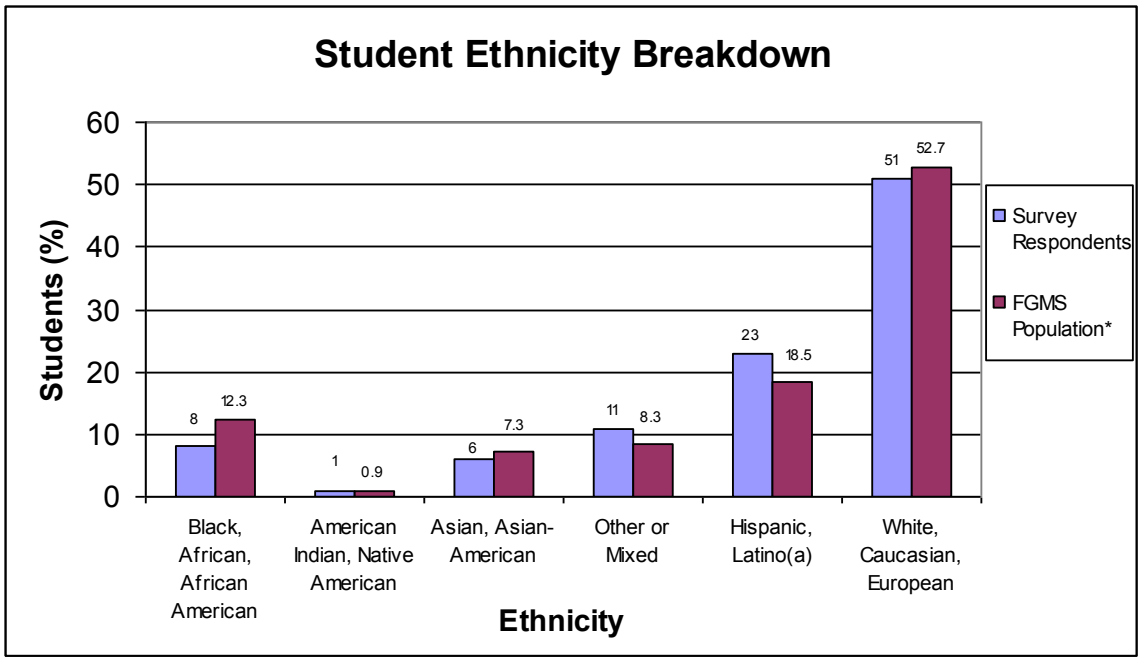
4. Data Analysis

Our review of pertinent literature led us to formulate a set of research questions. In order to answer these questions, we used student surveys, parent focus groups which included a survey, teacher interviews and analysis of existing data from the 2001 MCAS exams. It was necessary to analyze this data to look for correlations between student, parent and teacher opinions and actual scores on standardized testing. We began by analyzing the data from each method individually. Student survey data was entered into Microsoft Access and analyzed using frequency histograms. This data was normalized using percentages. The data collected during the focus groups with parents was transcribed and analyzed using content analysis for general themes, and the data from the survey given at the conclusion of the focus groups was analyzed in the same manner as the student surveys. Teacher interviews were also transcribed and reviewed by content analysis for common themes. The MCAS data was available only as totals and percentages of students scoring within each range. We produced graphs of this data in order to visually represent the information we were given. We also reviewed each multiple-choice question of the 2001 exam and searched for common themes among incorrect answers given. The results of these individual analyses were then compared in order to draw larger conclusions.

4.1 Student Surveys

Ultimately, the number of students surveyed was smaller than originally expected, as the estimate was made assuming approximately 25 students in each class, yet some contained as few as ten students. We surveyed a total of 417 students in 24 classes throughout the school. There were 214 male students and 203 females. The survey

included 167 students at the Honors level, 184 in Level 1 and 60 in Level 2. An equal number of classes (8) were surveyed at each level, but Level 2 classes tended to be considerably smaller. Survey data was analyzed using Microsoft Access and graphed to find trends and correlations. Figure 4.1 shows the ethnicity breakdown for the students surveyed.



*=Ethnicity titles and values taken from FGMS Student Attendance Grading Enrollment (SAGE) data management system

Figure 4.1: Ethnicity Breakdown for Surveyed Students

This breakdown is very representative of the overall student population, as the administrative software used at Forest Grove Middle School (FGMS) gave a value of 48 percent minority students and we surveyed 49 percent minorities.

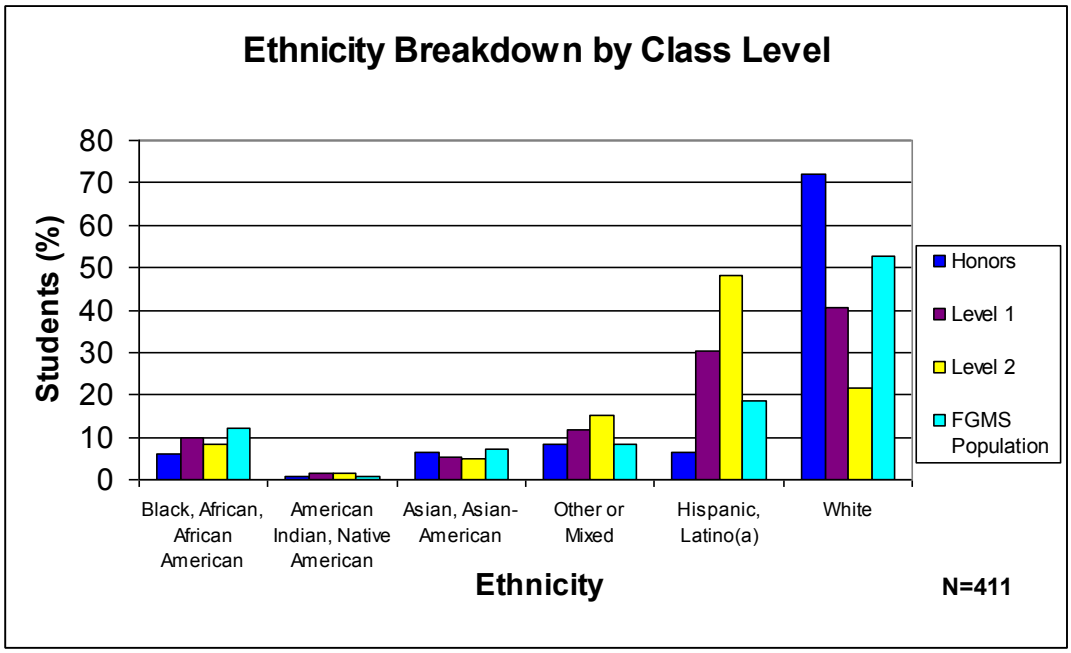


Figure 4.2: Ethnicity Breakdown by Class Level

Although our surveyed population was very representative of the target population of FGMS students, the distribution of this population between the three class levels is not equal. There is a relatively high percentage of Hispanic students in Level 2 classes and a relatively low percentage of White students in these same classes. The opposite is true for Honors level classes. This must be considered when viewing data by class level, as the opinions expressed may vary by ethnic group. A similar consideration must be made regarding gender, as the Honors classes surveyed contained 42 percent males and 58 percent females, Level 1 contained 56 percent males and 44 percent females and Level 2 contained 58 percent males and 42 percent females.

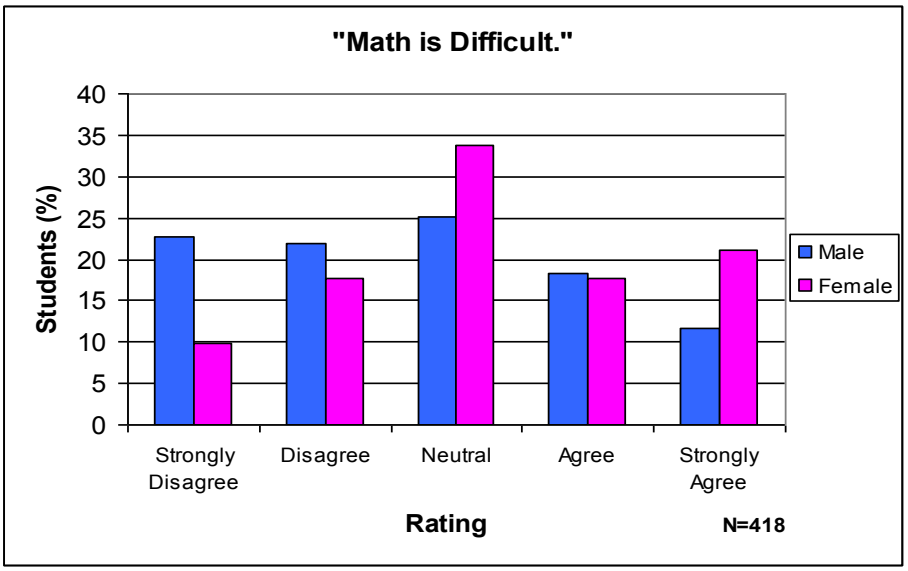


Figure 4.3: Students' Rating of Difficulty of Math by Gender

The students' rating of most of the items on the Agree/Disagree portion of our student survey (items 5-12) were fairly equal across the genders. Their ratings of the statement "Math is difficult," however, were significantly different. More girls strongly agreed with this statement, while more boys strongly disagreed. Although the self-reported grades were similar between the genders, indicating that their abilities were comparable, the disparity between genders on the rating of this statement signifies a vast difference in attitudes toward the subject matter.

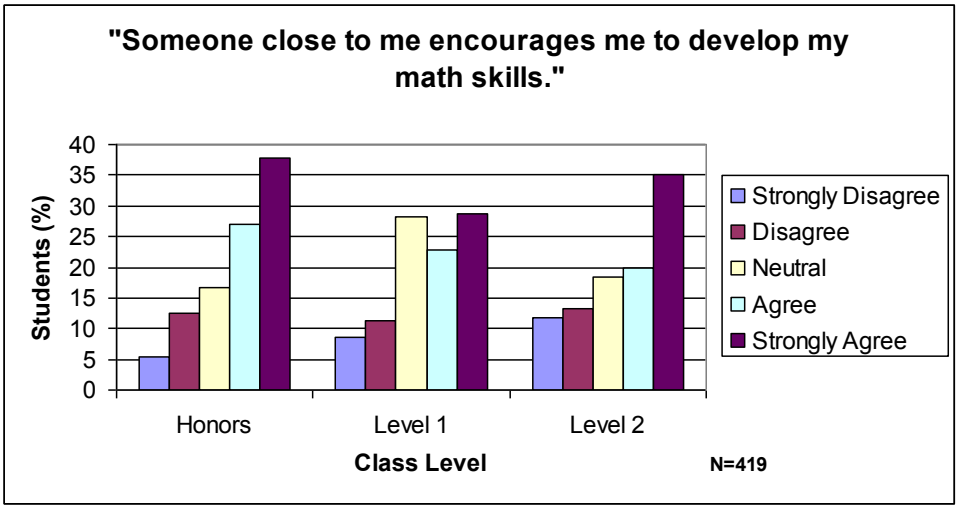


Figure 4.4: Students' Rating of Encouragement from Home by Class Level

As expected, the majority of students at the Honors level either agreed or strongly agreed with the statement "Someone close to me encourages me to develop my math skills." The percentage of students who strongly disagreed with this statement was highest in Level 2 classes, yet the majority still agreed or strongly agreed. The most meaningful data comes from the Level 1 response to this statement. During teacher interviews, most indicated that Level 1 students tend to have the ability to perform at the Honors level, but do not have the motivation and that Level 2 students generally have more motivation but are less capable of understanding the subject matter. This may be explained by the smaller percentages of Level 1 students who agreed or strongly agreed with this statement regarding encouragement. This is also supported by the students' response to the statement "I have someone who motivates me to do well in math," as can be seen in Figure 4.5.

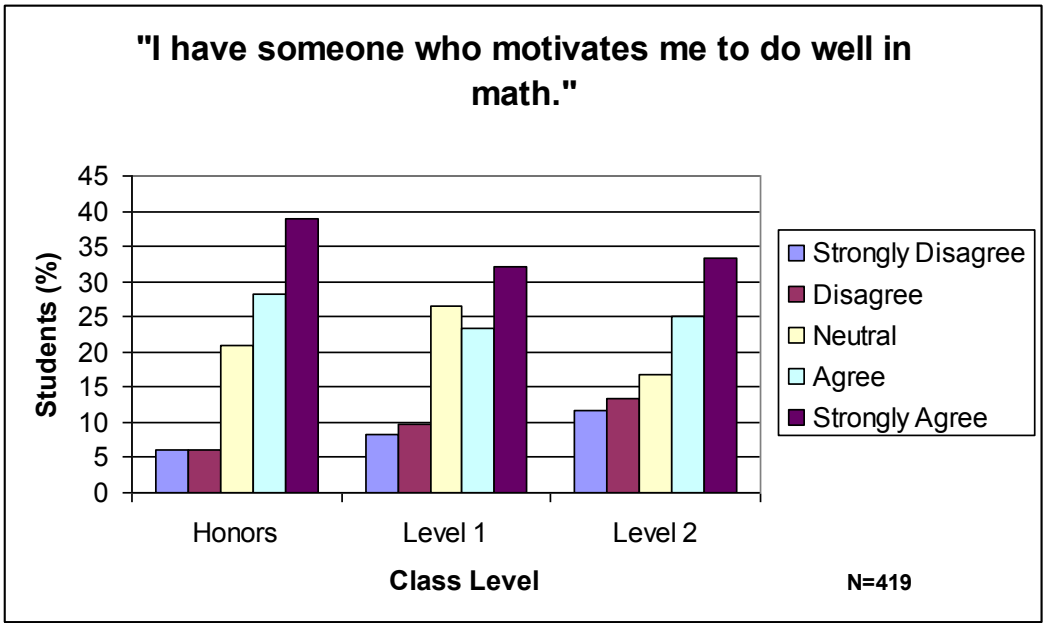


Figure 4.5: Students' Rating of Motivation by Class Level

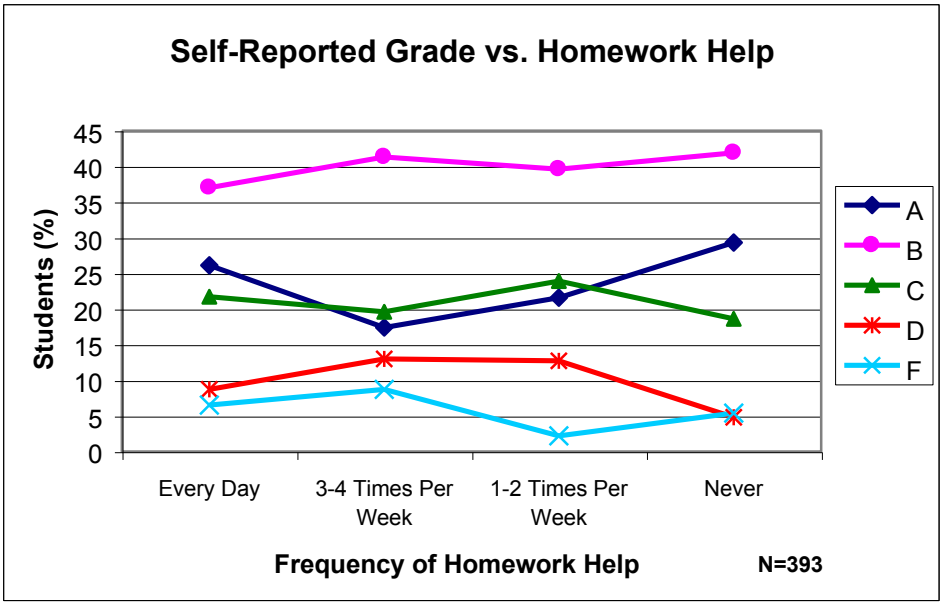


Figure 4.6: Grade in Math vs. Homework Help

If the frequency of homework help were directly related to a student's grade in math, then one would expect to see a the highest percentage of A's among students receiving homework help every day and the lowest percentage among students never receiving help. The opposite trend would be expected of D's and F's. Figure 4.6 shows that this is not the case. Even among students receiving homework help every day, the percentages of A's and C's are nearly equal. Surprisingly, there is a larger percentage of students who never get homework help receiving A's than there is receiving C's. The lack of overall improvement with more frequent help indicates that parents most likely are unsure of the best way to help their children with homework problems. The most disturbing trend is that most students indicated that their parents never helped them with math homework.

Overall, our student survey gave us valuable insight into the demographics and attitudes of students at FGMS. Through analysis, relationships were found between variables tested, although some showed stronger correlations than others. The

differences between the genders emerged not on performance questions, but on questions regarding attitudes, indicating that the abilities are equal between genders, but the views of the subject matter are not. Larger differences were seen between class levels. More Honors and Level 2 students indicated that they had support from home than students in the Level 1 classes. This support, however, may not be as helpful as possible, as no strong correlation was found between frequency of homework help and a student's grade in mathematics. These conclusions drawn from the data collected using the student survey are limited, as they only consider one aspect of a larger problem – lack of enrollment in technology/engineering programs. Data from parents, teachers and standardized testing must also be analyzed in order to provide a more detailed view of this issue.

4.2 Parent Focus Groups

Originally, three focus groups were planned. They were to take place on April 2-4, 2002 from 6:30-8:00 PM each evening. The groups on April 2 and 3 were to contain parents of students not currently enrolled in the Engineering cluster. The group held on April 4 was to contain parents of students already enrolled in the Engineering cluster. Due to lack of response from the non-engineering parents, we were forced to make several changes to our methodology. A detailed description of these changes can be found in section 4.2.2.

4.2.1 Discussion

Six parents of students enrolled in the Technology/Engineering Cluster attended the group held on April 4, 2002. In order to initiate discussion, a brainstorm sheet containing very broad topics was distributed. Parents were asked to write down their initial reactions to a set of three questions on current math programs at FGMS, availability of outside help and communication with teachers (Appendix I) and any other suggestions or concerns they may have regarding mathematics at FGMS. The discussion followed the order on the brainstorm sheets, and parents were asked to read aloud from their sheets, then to respond to what others had said. As suggestions were made, they were written on a board at the front of the room. At the conclusion of the discussion, a survey was distributed to obtain demographic information and to rank the suggestions made during the group.

The final survey item, number 19, originally stated, "Using the suggestions listed on the board, please choose five in which you would be most likely to participate and rank them from 1 (most likely) to 5 (less likely)." However, many of the suggestions made were not programs in which parents would participate, so the moderator instructed the participants to answer this question as if it asked for the most useful suggestions to them or their children. The nature of the suggestions made may indicate that parents expect the school to be providing programs for their children, but are only willing to participate to a certain extent. Many parents indicated that they were not available during the hours immediately after school ends due to jobs and other time constraints. They did, however, state that if they were made aware of school programs, they would be willing to actively encourage their children to participate.

In order to determine the top suggestions, the responses to question 19 were given 5 points for a top ranking, 4 points for a second ranking, etc. All suggestions made and the number of points each received can be found in Appendix J. The top five suggestions were as follows:

1. Parent guides/meetings to helping with homework. Parents agreed that some form of a guide would be helpful in helping their children with homework. Many indicated that they did not remember the material their children were learning. Even those parents who did recall the subject matter found that the problem-solving methods being taught were quite different from those they had learned. They would like the school to either create a parent guide, hold meetings where teachers explain their methods, or provide information for parents to purchase the manual corresponding to the textbook used.
2. Better and more personal communication between parents and teachers. The interim reports sent home halfway through each grading period were recently transferred onto an electronic system. Prior to this change, teachers were able to include hand-written personal comments on each student's report. With the use of electronic reports, teachers select a pre-written comment such as "Shows weakness in computation" or "Weak in comprehension" by choosing a number on a form. These reports are mailed home directly from a central office for the entire city of Worcester. The parents who attended our focus groups indicated that these reports often leave questions regarding the actual performance and preparedness of their child, as the pre-written comments tend to be vague and do not give suggestions for improvement. For example, one parent stated that s/he was only told his/her student was not ready to enter an

advanced mathematics class in high school at the time of course selection with very little time remaining in the school year. S/he felt that if this message had been sent home in a personal note sooner, the student would have had time to seek outside help to improve his/her understanding of the subject material. This parent said, "My [child]'s grade is a B, so…I [do not] think s/he needs extra help."

3. Peer/honors tutors. Parents at the focus groups suggested that students in the honors classes at FGMS or local high schools be offered the opportunity to work with students in need of tutors at FGMS. Parents indicated that their children respond better to someone closer to their own age than a parent or a teacher.
4. College tutors. Parents pointed out that there is a large number of college students within the city of Worcester, and many of them are required to perform community service. They suggested that FGMS offer community service hours to these college students for tutoring students in need of their help. WPI students are already offering a tutoring program for FGMS students, however in the opinions of the parents at the focus groups, the program was not promoted, as it should have been.
5. Homework groups. Parents suggested that teachers organize homework/study groups for the extended homeroom activity period in which students work on homework together. Ideally, these groups would be well-mixed, containing both students with a strong grasp of material and students who may be struggling. Parents felt this would create an opportunity for students to learn from each other.

4.2.2 Parent Survey

At the conclusion of the focus groups, a survey was distributed (Appendix E). Parents were asked to give demographic information and to answer questions regarding

their knowledge and opinions of FGMS mathematics programs. Only one non-engineering parent attended the focus group planned for April 2, 2002. Due to lack of response, the focus group scheduled for April 3, 2002 was cancelled. As the non-engineering parents were not able to attend the focus groups as planned, we administered a phone survey in order to gather some data from this portion of the population. The same survey taken by seven parents during the focus groups was given over the phone with the exception of the final question, number 19, which was rewritten to fit the phone format (See Appendix H). This allowed the data from both survey styles to be combined and graphed. Item number 19 was used to determine the top five suggestions from the focus group as described in section 4.2.1. The corresponding item on the phone survey was used to find whether non-engineering parents supported these suggestions as well.

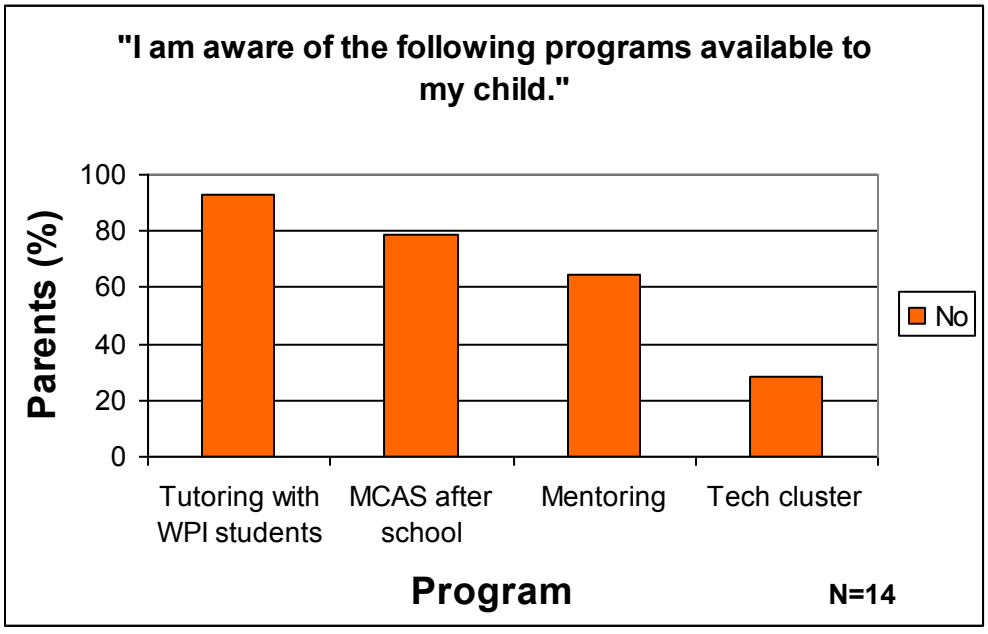


Figure 4.7: Parents' Knowledge of Opportunities Available for Their Children

Figure 4.7 shows evidence for a lack of communication between FGMS and parents. The only program that was familiar to a majority of parents was the Technology cluster, and this is a program available during school. Very few parents indicated that

they were aware of opportunities available outside the school. This supports our findings during the discussion in which parents recommended a college volunteer tutoring program as a top suggestion, yet this program already exists with students from WPI.

The results of our focus group discussion are further supported by Figure 4.8. Parent guides and meetings where teachers give instructions for helping with homework was rated as the top suggestion for improving mathematics performance. Only three of the 14 parents surveyed indicated that they strongly agreed with the statement, "I am comfortable working with my child on his/her homework." Parent guides and meetings could serve to make parents more confident when helping their children with homework.

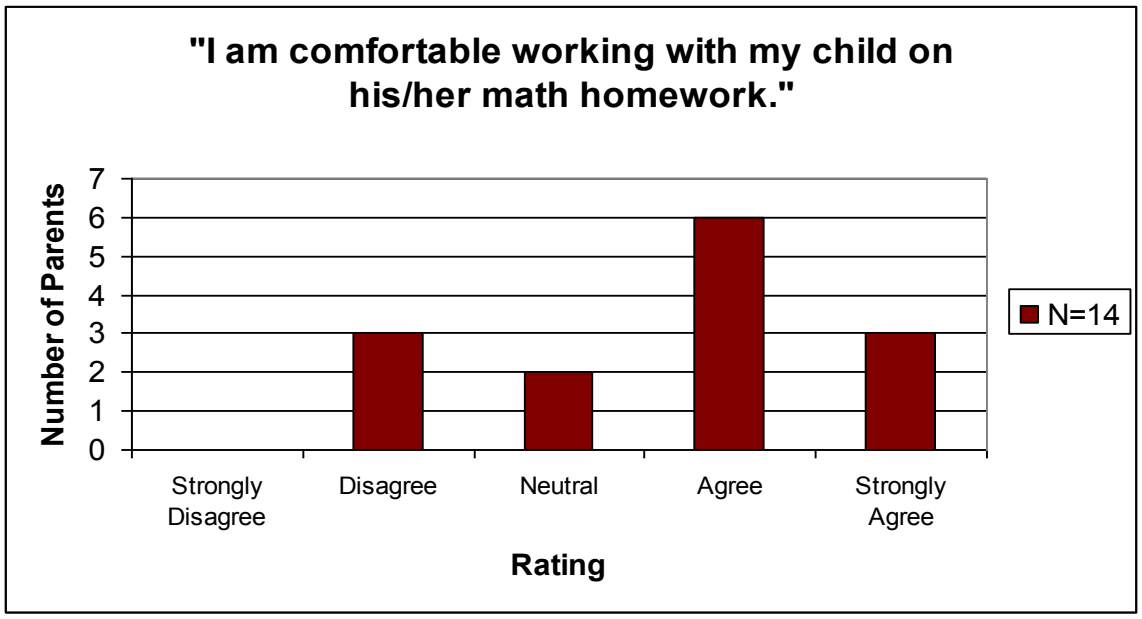


Figure 4.8: Parents' Rating of Confidence When Helping With Homework

The suggestions listed in section 4.2.1 were also supported by the parents who participated in our phone survey. Figure 4.9 shows that all seven supported parent guides or meetings and better/more personal communication. The only suggestion that was not supported by the non-engineering parents surveyed was the organization of homework groups. This could be due in part to parents' fear of their child relying on a group to do

work. Both suggestions that include middle school students working together were rated lower than the others listed. This indicates that parents lack confidence in their children's ability to work independently. Parents at the focus group indicated that students at this age require at least some form of structure in their learning environment to avoid social distractions.

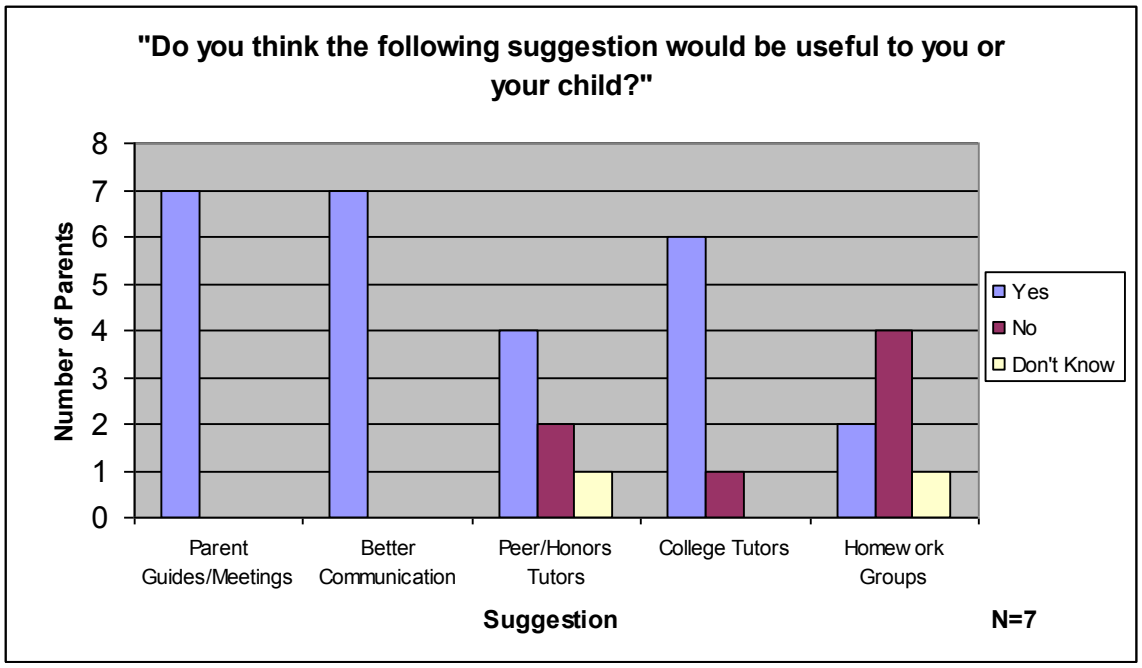


Figure 4.9: Usefulness of Top Five Suggestions

4.2.3 Summary of Parent Focus Groups

Support from parents is vital to the success of any school program. Thus, the data collected from parents may be most pertinent to our final recommendations. Parents indicated that they would be better able to take an active interest in their children's education if they received more information from the school. Guides on how to help with homework and personal notes summarizing a child's performance would be beneficial, as would better promotion of current programs available to students. Parents feel their children are more apt to respond to help from someone closer to their own age, although

students are still not likely to seek help if the decision is left in their hands. Parents, therefore, need to be more heavily involved in decisions regarding their children's education. This can only be done through better communication between school and home. In order to help develop this interaction, teacher attitudes and methods must be investigated.

4.3 Teacher Interviews

We interviewed all eight math teacher at FGMS in order to study the effects of teacher attitudes and practices on the success of their students. Each interview lasted an average of 25 minutes. The interviews followed a structured set of questions found in Appendix G. Recordings of the interviews were transcribed and a content analysis was performed by each member of the group in order to provide inter-rater reliability. Several common themes emerged:

1. Personality and past experience, rather than gender or ethnicity, lead a student to volunteer in class.
2. A comfortable environment is important to student performance.
3. The subject matter must be presented in a way that holds student interest.
4. Parental response overall is poor.

All eight teachers indicated that the tendency of a student to volunteer was dependent on his/her personality as opposed to gender or ethnicity, although personality could be attributed to the amount of encouragement received at home. Fear of ridicule from peers was also a common reason mentioned when teachers were asked about trends in volunteering. Teachers also indicated that they use different methods to encourage students to volunteer depending on class levels. Lower level students are given more

positive reinforcement and the teachers point out what is correct about any answer. For example, teacher 7, when asked how s/he encourages students to volunteer, said, "[I] eliminate the fear factor and eliminate negative experiences volunteering or demonstrating problems. Find some sort of positive whether the work is right or wrong. Find the good part about it and emphasize it." Honors level students can be motivated using comments such as "You are not acting like an Honors class," which may be seen as negative, drawing on their will to succeed.

Anything that promotes a comfortable home-like environment was also strongly supported by math teachers for improving student performance. Most indicated that when students are comfortable, they are more likely to pay attention in class. Some examples of promoting a home-like environment include giving candy rewards during math games, keeping plants in the room or playing a radio station students choose while they do their work.

Although teachers keep students' attention using a variety of methods, they all agree on the importance of keeping the subject matter interesting for students. "You have to be an Academy Award performer. It's more performing than teaching" (Teacher 8). All teachers agreed that randomly calling on students helps keep their attention by "putting them on the spot." One teacher uses board problems that require a series of steps, having each student fill in a step or an answer. This means students must pay close attention to the entire problem so they will be prepared when their turn comes. Several teachers also mentioned that they vary their voice level and move around the room to keep students interested.

The main problem mentioned by all teachers was poor response from parents. The FGMS Guidance Office sets up parent meetings at teacher request, but oftentimes parents agree to whatever is said during a meeting and fail to follow through on this agreement at home. Teacher 4 referred to this when s/he said, "A lot of parents, when they come into meetings,…talk a big game, but there's not much follow through at home. If there's no consistency at home, you can just tell." Teacher 5 agreed, saying, "I call it whitewash. Anything you say, they write down and agree with, you know, 'Right, right, right!' but come next week when you're looking for their signature on an agenda book, it's not there." A number of the teachers voiced concerns about not seeing the parents with whom they would most like to meet regarding their child's performance or behavior. This leads to a cycle of poor behavior or academic performance by the student and failed attempts to contact home.

Although many of the teachers agreed on most topics, we found conflicting opinions regarding the use of games and group activities in class. Many teachers praise fun activities as a means to get the students involved. On the other hand, one criticism of games is that students fail to learn the intended skills. For instance, teacher 6 said, "I [have] got kids coming to me from six years of elementary school playing games who can't add. They [do not] know their multiplication tables, they [do not] even know how to set up a division problem because all they [have] been doing is playing games. I [am] still trying to play catch-up with basic skills…so I [do not] focus a lot on making it fun for them." Similar opinions were expressed regarding group work, where teachers employ group activities to allow students to teach each other while avoiding a monotonous lecture. One weakness of this strategy, as stated by teacher 6, is "A lot of

group work with 13- and 14-year-olds turns into a social hour, so you get very little done. You get the aggressive leaders who do all the work and the passive 'don't-really-cares' who just copy it." It is important to find a balance between lecturing that teaches skills and fun activities that reinforce skills and hold interest.

In an effort to provide a different perspective on the problem, teacher interviews were used. The interviews supplied both opinions on why teachers think students show a lack of interest in the material and suggestions on how to address this. Most teachers agreed on several common themes. The first is that a student's personality plays the largest role in whether or not they are going to volunteer. The next theme is that a comfortable environment helps the student to focus better on the subject. Another theme is that a teacher must present the subject matter in a way that holds a student's interest. All teachers agreed that parental response was lacking. The data provided to this point, was through personal opinions and suggestions, thus a more concrete source such as standardized testing results must be used in order to supply further information.

4.4 Analysis of MCAS Data

We were able to use only the most recent data from the MCAS testing, as the grading standards were changed between the 2000 tests and the 2001 tests, making the data incomparable between years. We used the breakdown of MCAS scores provided by the State of Massachusetts to FGMS. This included information regarding racial/ethnic background, gender, performance level and average scores. We also had access to the individual questions and answers from the 2001 tests, as well as what percentage of students chose each answer for multiple-choice questions. Questions were placed in categories by both question type - multiple choice (MC), short answer (SA) or open

response (OR) - and reporting category - number sense (NS), patterns, relations and functions (PR), geometry and measurement (GM) or statistics and probability (SP). A description of the expected knowledge for each category at the eighth grade level is available from the MDOE web site, http://www.doe.mass.edu/frameworks. We used this data to produce charts of success level of students versus the demographic information or question categories.

The state of Massachusetts places students into four categories depending on their score. The highest category, Advanced, applies to students scoring between 260 and 280 points. According to the MDOE (2001), "[S]tudents at this level demonstrate a comprehensive and in-depth understanding of rigorous subject matter, and provide sophisticated solutions to complex problems." The next highest performance level is Proficient and includes students scoring between 240 and 259 points. Students at this level are described as "demonstrat[ing] a solid understanding of challenging subject matter, and solve a wide variety of problems." The third performance level is Needs Improvement and includes students scoring between 220 and 239. The MDOE describes these students as "demonstat[ing] partial understanding of subject matter, and solve some simple problems." The last performance level is Warning and includes students that score between 200 and 219. "Students at this level demonstrate minimal understanding of subject matter, and do not solve simple problems."

4.4.1 Student Performance

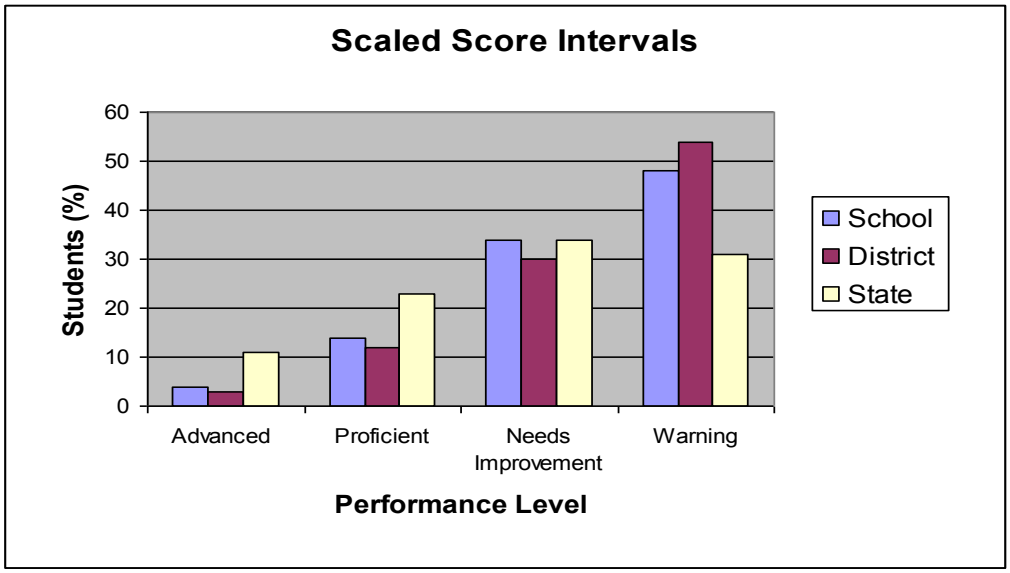


Figure 4.10: Performance Level of Forest Grove Middle School Compared to District and State

The average score on the Mathematics portion of the MCAS test for FGMS students was 225 points out of a possible 280. This is slightly higher than the Worcester District average of 223, but lower than the State of Massachusetts average of 233. Also, a larger percentage of FGMS students scored at the Advanced and Proficient levels than the overall percentage in the City of Worcester. Fewer FGMS students fell in the Warning level category than the district average, yet the state percentage of students at this level is lower than that of FGMS. This indicates that FGMS is already achieving scores above the Worcester average, but still needs improvement to reach the Massachusetts average.

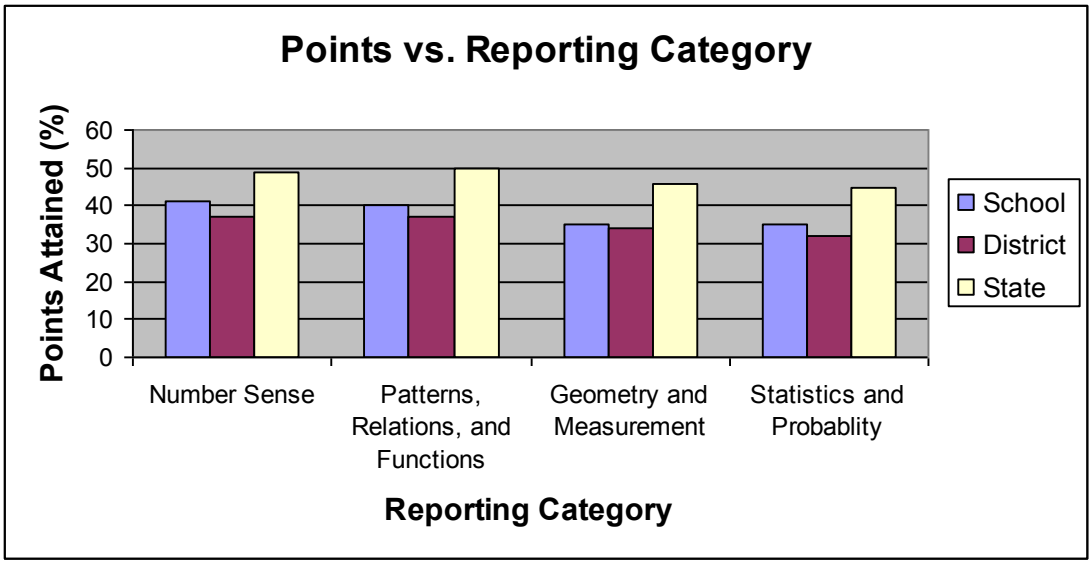


Figure 4.11: Average Points Achieved per Reporting Category

Consistent with district and state trends, FGMS students scored best on "Number Sense" questions. They scored lowest on questions testing knowledge of "Statistics and Probability." FGMS students were above the district average for all categories except "Geometry and Measurement", in which the school and district scores were nearly the same. The state's scores in all categories were approximately ten percent higher than FGMS scores.

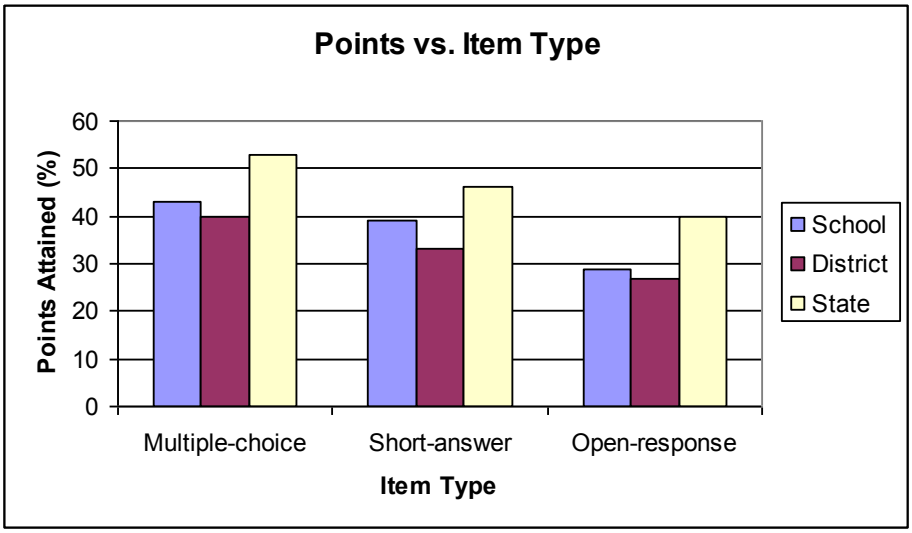


Figure 4.12: Average Points Achieved per Question Type

FGMS students received the highest percentage of possible points on multiple-choice questions. This indicates that students were better able to choose from a list of possible answers than to produce an answer of their own. The percentage of total points attained on short answer questions indicates the percentage of correct responses given, as students were either given one point for a correct response or zero points for an incorrect response or blank answer space. This percentage may be misleading, as it was lowered significantly by a relatively small number of questions. For example, 78 percent of FGMS students received zero points on item 7 of the test, a short-answer number sense question. Overall, students received the lowest percentage of possible points on open response items. Although this item type allows for partial credit (it is graded on a scale from 1-4), many students received no points, presumably because they left the item blank. For example, 50 percent of FGMS students received zero points on item 23 of the test, an open response statistics and probability question. Further analysis will attempt to explain why students did not receive any points on this and other similar items.

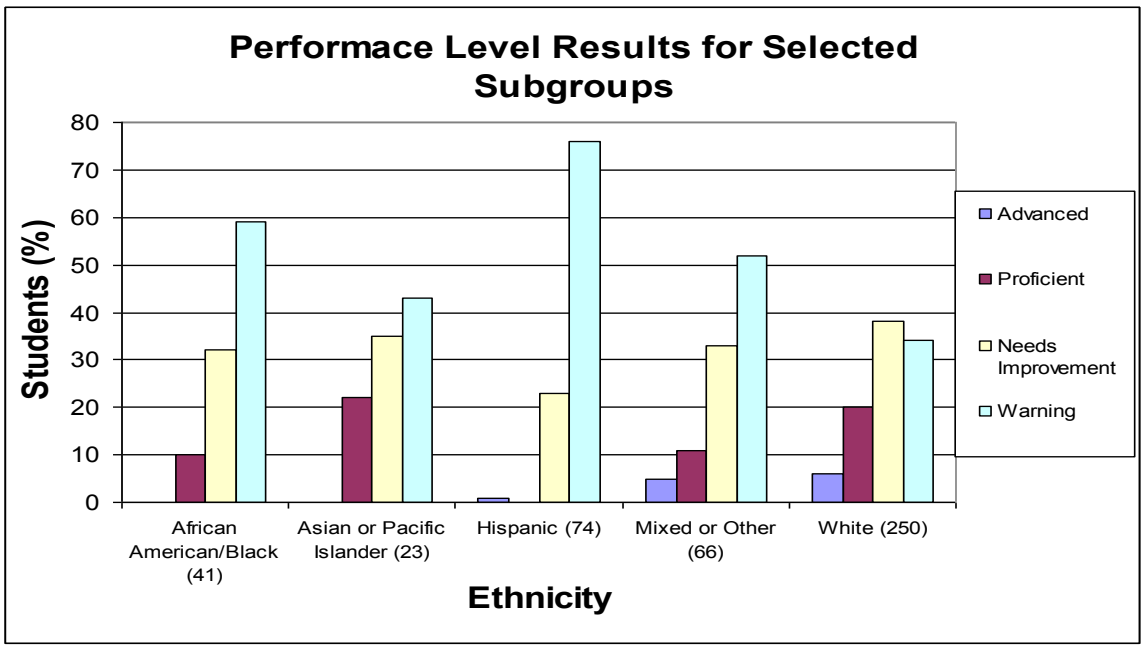


Figure 4.13: Performance Level Breakdown by Ethnicity at Forest Grove Middle School

It can be seen from Figure 4.13 that all ethnic groups follow essentially the same distribution pattern, with the lowest percentage of students at the Advanced level and the largest percentage at the Warning level. The only exception is the group of 250 white students, where the largest percentage fell into the Needs Improvement category, although the percentages at the Warning (34%) and Needs Improvement (38%) levels are very close. The overall trends for Asian/Pacific Islander students may be the least significant, as only 23 students out of 467 tested were of this ethnic background. Similar problems arise when analyzing the data for African American/Black students, as only 41 students tested were of this ethnic background. The most significant data comes from the Hispanic group of 74 students, where only 1 percent of students fell in the Advanced category, no students were in the Proficient category, 23 percent received a rating of Needs Improvement, and 76 percent fell into the Warning category. By observing this graph, it becomes clear that all ethnic groups need nearly equal improvement to fall within the desired categories of Proficient and Advanced.

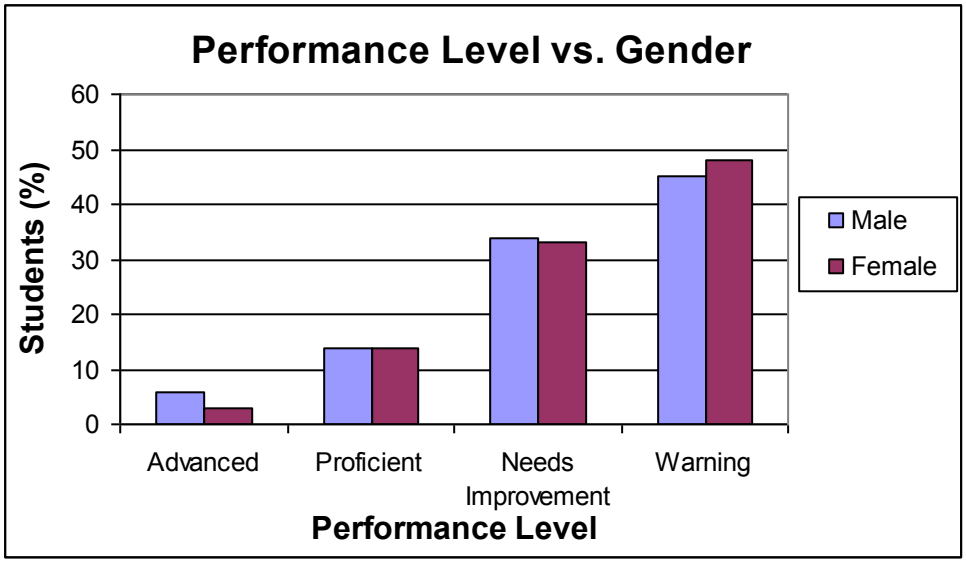


Figure 4.14: Performance Level Breakdown by Gender

Figure 4.14 shows the trends for both genders are similar. The numbers of students of each gender were equal, at 228 each. The most significant difference between genders is seen in the Advanced category, which contains twice as many males (6%) as females (3%). This could pose one possible explanation for the smaller number of girls entering advanced math classes in high school, as they are receiving lower scores at the middle school level.

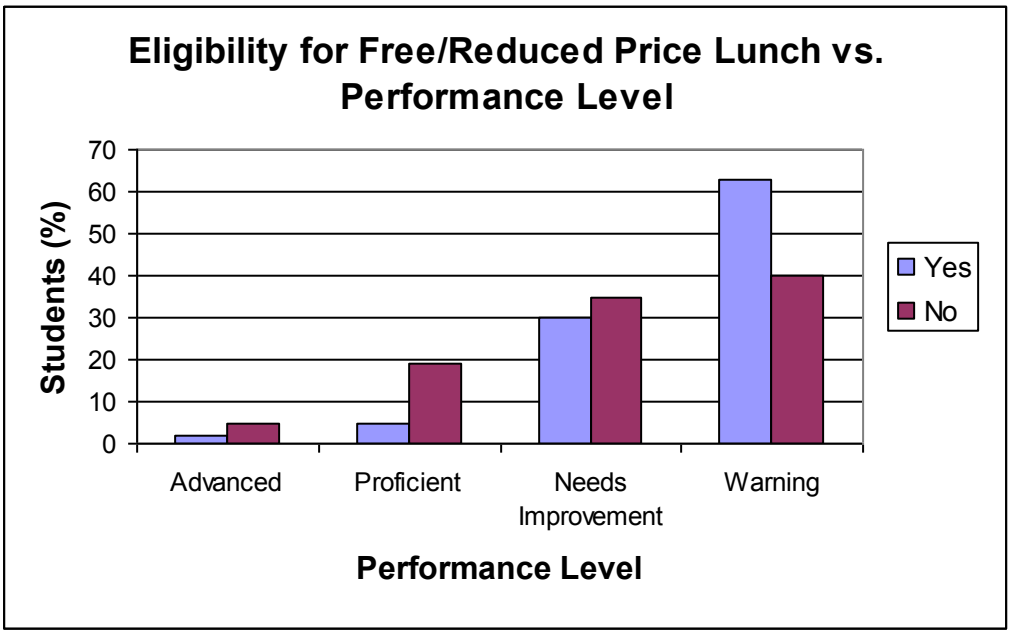


Figure 4.15: Effects of Socio-economic Status on Performance Level

The Worcester Public Schools' Department of School Nutrition offers a Free/Reduced Price Lunch program to students from eligible families. Eligibility is determined on the basis of household income per household size. A weekly income base of $306 is assumed for a household of one and $108 is added for each additional member of the household. If a family makes less than the specified amount for its size, the children are able to receive lunch either at half price or free, depending upon how far

below this amount the actual income is. Families who care for foster children are automatically eligible for free lunch, regardless of household income.

Using eligibility for free/reduced price lunch as an indicator for socio-economic status, Figure 4.15 shows that socio-economic status has a strong effect on the performance of the students tested. A significant portion (31%) of students tested were eligible for free or reduced price lunch. Of these, only seven percent placed in the desired upper two categories, compared to 24 percent of ineligible students. A large difference is also seen in the Warning category, containing 63 percent of eligible students versus 40 percent of ineligible students. In order to account for these differences, more attention must be focused on the eligible students and their academic needs.

4.4.2 Multiple Choice Analysis

We examined all multiple-choice questions from the 2001 MCAS mathematics test for 8^{th} grade. We compared the incorrect answer that was chosen by the largest percentage of students to the correct answer to investigate possible reasons for students' choosing the incorrect answer. Student performance on specific multiple-choice questions indicates several gaps in knowledge expected at this grade level. On many questions, students show a lack of understanding of the language of mathematics, including symbols and words not commonly used in other areas. Similarity in answer choices seems at times to have caused confusion. An overall lack of algebra skills is also a major contributing factor to poor scores.

Students demonstrated an overall lack of understanding of the language of mathematics. They seem to have chosen incorrect answers due to an inability to

associate mathematical symbols with an appropriate operation. Definitions of mathematical terms also posed problems. For example, item 2 of the 2001 exam asked:

"2. Which is the **best** approximation of $\sqrt{72}$?

A. 7.2
B. 9.1
C. 8.9
D. 8.5"

Many students were unable to translate the symbol and take the square root of the number, as 42 percent chose the correct answer, D, but 31 percent chose A instead. This number contains the same two digits as the number in the problem, 7 and 2, and may have drawn students who did not understand the question due to the symbol. Another example is item 31 of the 2001 exam, which gave a list of five numbers, 81, 86, 96, 93 and 84, and asked what the sixth number should be "to have an overall mean of 90." Only 32 percent of students chose the correct answer, 95, yet the other three answers, 89, 92 and 97 received 21 percent, 24 percent and 21 percent of responses respectively. The fairly even spread indicates a misunderstanding of the definition and appropriate operations indicated by "mean."

In order to truly test students' knowledge, the MCAS test uses very similar answer choices that make guessing difficult. Students were often misled by these similar choices. For example, item 5 of the 2001 exam asked:

"5. A hole in a piece of metal has a diameter of 3 ½ inches. Which of the following pipes is the largest that will fit through the hole?

A. a pipe with a diameter of 3 $^{3}/_{8}$ inches
B. a pipe with a diameter of 3 $^{7}/_{8}$ inches
C. a pipe with a diameter of 3 $^{5}/_{16}$ inches
D. a pipe with a diameter of 3 $^{7}/_{16}$ inches"

Only 31 percent of students tested chose the correct answer, D. Answer A was chosen by the largest number (35%) of students, followed by answer B with 24 percent of responses. All four possible choices are within $^{9}/_{16}$ of each other, leading to a very large percentage of students choosing incorrect answers.

Simple algebra problems also confused a number of students. This is likely due to the fact that only half of the students in the 8th grade at FGMS currently take Algebra, yet all are expected to answer questions involving algebraic operations. For example, item 37 of the 2001 exam asked:

"37. Which of the following describes one way to solve this equation?

$12 - 3x = 5$

A. Add 3x to both sides, then divide both sides by 3
B. Subtract 3x from both sides, then multiply both sides by 3
C. Add 12 to both sides, then multiply both sides by –3
D. Subtract 12 from both sides, then divide both sides by -3."

Assuming that only half the students tested had the algebra skills to answer this question, then it is reasonable that 40 percent chose the correct answer. Looking at the overall distribution, however, shows that 22 percent chose answer A, which violates order of operations, a basic rule of algebra. Graphing on an X-Y axis is also included in the Algebra curriculum and tested on the MCAS exam. An average of 40 percent of students tested got graphing problems wrong. This illustrates another problem area relating to algebra skills. Beginning in Academic Year 2002-03, all eighth grade students at FGMS will have the opportunity to take Algebra, hopefully leading to more correct answers.

4.4.3 Summary of MCAS Analysis

Overall, the MCAS data gave us valuable insight into the student performance on standardized testing. While the scores of FGMS students exceed the district average, they are not as high as the state average. In order to identify areas in need of improvement, relationships between item type, reporting category, racial/ethnic background, gender, socio-economic status and average score were examined. FGMS students performed best on test items relating to "Number Sense" and worst on items testing "Statistics and Probability." They received the lowest percentage of possible points on open response questions. White students performed best on the tests, while Hispanic students performed poorly. This could indicate gaps in reading/language skills leading to an inability to answer questions properly. The genders showed fairly equal performance levels, although twice as many males as females placed in the advanced category. As students continue into high school, this disparity becomes more pronounced, as fewer females choose to pursue advanced level mathematics classes. Socio-economic status showed a great impact on student performance. Students who were eligible for free or reduced price lunches scored significantly lower than students who were not eligible for this program.

We also analyzed multiple-choice questions in an effort to pinpoint gaps in student knowledge. Students showed a lack of understanding of the language of mathematics. They also demonstrated an inability to distinguish between similar answer choices, along with a lack of algebra skills. These conclusions are limited by the fact that test scores from the 2001 exam are not comparable to the scores from 2000.

4.5 Summary of Analysis

By analyzing the data we have collected using each method, a number of conclusions can be drawn. Student surveys showed larger differences between class levels than between genders or racial/ethnic backgrounds. These differences are largely based on support from home and attitudes toward the subject matter, for even students with equal abilities show vastly different opinions from one class level to the next. Parent focus groups indicated a serious need for more communication and interaction between parents and the school, whether directly related to their child's performance or to overall opportunities available. Teacher interviews supported conclusions drawn from survey data and provided views similar to those of parents concerning the lack of communication between parents and the school. Our analysis of MCAS scores and testing items identified weak areas in student knowledge and will allow for better recommendations to be made on how to strengthen these areas. Although these conclusions drawn from each individual method provide some insight, they each consider only one aspect of a larger problem. By comparing these conclusions between methods, greater conclusions can be drawn and recommendations for improvement can be made.

5. Conclusions

Our study identified the areas of the Forest Grove Middle School (FGMS) mathematics programs that could be strengthened to improve student interest and skill. In order to get a complete understanding of the FGMS community, we used data collected from students, teachers, parents and past testing data. From our research, current mathematics programs could be improved upon and new, effective programs could be developed. Working specifically with the suggestions we collected from parents, FGMS could build a stronger relationship between school and home, creating a better learning environment for students.

By using four methods, and seeing that they complemented each other, we verified that the results of each method were accurate. Data collected from the student survey was compared to statements made by parents at focus groups and during the phone survey to determine if parents and students were effectively communicating. Statements made in teacher interviews were compared to answers given on the student survey to see if the teachers' methods and practices were reaching the students as intended. Comparisons between all four methods allowed the larger conclusions in section 5.1 to be drawn. From these conclusions, we have made the recommendations found in section 5.2. We have described the limitations of our study in section 5.3.

5.1 Areas for Improvement

One concern that developed from our study was a lack of communication on all levels. There is very little communication between teachers within FGMS, as well as between teachers at Doherty High School (DHS) and FGMS. The eight teachers interviewed at FGMS gave vastly different answers to some questions, particularly

regarding the use of "fun" activities in the classroom. Some indicated that such activities enforced skills, while others felt they led to a destructive social atmosphere from which students did not gain the intended skills. In order for the transitions from one grade to the next to run smoothly, teachers must ensure that the required skills are taught by the specific teaching method they employ. If a student does not leave the seventh grade with the necessary skills, his/her eighth grade teacher is faced with the pressures of teaching both those skills and the skills required to be taught at this level. FGMS is also enforcing a set of standards that do not necessarily apply for DHS programs. Poor communication between the schools has led to students not being recommended for the highest ability levels possible. For example, one parent indicated that his/her child was told by FGMS that without an 88 percent average in Algebra, s/he would not be able to take Geometry at DHS. When this parent called DHS directly, s/he was told that unless the student was failing Algebra, s/he could take Geometry. This is leading to fewer students continuing into higher ability level classes at DHS.

Communication between parents and teachers was also found to be inadequate. Parents indicated that they were not made aware of the opportunities available to their children. They felt that decisions regarding tutoring, homework and course selection were too often left in the hands of 12- and 13-year-olds who, as one parent said, "when given the choice between pizza and vegetables, will always choose pizza," meaning that students at this age often choose the easy way out. On the other hand, teachers feel that they are not getting appropriate responses from parents when communication is necessary. Current methods of communication between teachers and parents must be scrutinized and improved upon.

Parents also indicated poor communication with their children. They felt this stemmed from normal developmental changes and a desire for independence common at the middle school age. Parents also felt the school depended too much on the responsibility of their children, yet not all 12- and 13-year-olds are responsible enough to set priorities and meet deadlines on their own. Although children at this age are beginning to develop a sense of independence, parents still need to be involved in their child's education, and an effort must be made at school to encourage this interaction at home.

Another major concern that arose from our research was a lack of effort by middle ability level students. Students in Level 1 math classes indicated on our survey that they did not feel they had encouragement from home to excel in math or the necessary outside motivation. All eight teachers agreed that the students at this ability level possessed the skills necessary to perform at the Honors level, but lacked the dedication of an Honors student. Teaching methods used with these students should be examined to find possible ways to provide the motivation that may be missing at home from within the school.

From our analysis of MCAS data and everyday interaction with students while distributing our survey, we found a general deficiency in reading comprehension on mathematics problems. Students scored poorly on questions using terminology and symbols specific to mathematics. They also lost a considerable number of points on open response questions, as many of them left these questions blank. Students lacked the ability to read, process and perform the operations necessary for solving a word problem. Thus it is important for such skills to be reinforced in the classroom and on homework.

The results proved a number of our original hypotheses, yet disproved others. Socio-economic status has a strong impact on performance level, as shown by MCAS data. Gender and ethnicity have less of an influence on success in mathematics than do ability level and parental involvement. Parents, teachers and MCAS scores indicated that the genders are fairly equal in ability and interest in mathematics. The same was true for the various ethnic groups studied. This contradicts some of the stereotypes we found in our literature review, but indicates that recent efforts to increase female and minority success in mathematics have been successful at this level and that the disparity occurs in the transition from middle to high school. Our research found that gender had a lesser impact than expected on success in mathematics, although the attitudes of males versus females tended to differ more than the abilities. More females than males strongly agreed with the statement "Math is difficult" and more males strongly disagreed with this statement. This could be a possible reason for the smaller numbers of females enrolling in advanced level mathematics courses in high school.

5.2 Recommendations

Many of our recommendations have been suggested and supported by parents. The first is parent guides and meetings, which can be done in many ways. Two possible ways are by chapter or by grading quarter. If the school chose to use parent guides, they could hold meetings that will allow them to understand the material better. The guides could be adapted from the teacher's lesson plans. Once the guides were created they could be reused yearly. They may be able to keep a copy in the library as a useful resource for new teachers. The guides could be sent home by mail, with the student or can even be posted on the web. If the textbooks have a supplement, the ordering

information needs to be provided to the parent or a copy should be available in the library.

Another recommendation, one that absolutely must be applied, is better and more personal communication between parents and the school. Our analysis found that parents are not aware of many of the opportunities for outside help available to their children. A number of the suggestions made at the focus group already exist, but promotion of these programs has been lacking or ineffective. One problem could be that parents receive a long list of programs, many of which do not apply to their child, and disregard the entire list, although some may be useful. If, for example, a publicity flier were made promoting two to three programs rather than a longer list, parents may be more likely to take the time to read this publication. Another problem could also be that information was sent home, but never reached parents. One possible solution could be requiring a parent signature for items that may pertain to a decision. Another, more personal solution could be the use of e-mail or handwritten notes to develop a direct interaction between parents and teachers.

A third possible program could be the organization of peer/honors tutoring. Honors students could tutor other levels or each other in subjects where they perform well. This could be rewarded using extra credit points or discounts on yearbooks, dance tickets, etc. One drawback of this program would be the requirement of close supervision to prevent a "social hour." Another possible source of tutors would be the Engineering Pipeline or other Honors classes at DHS. These students are still close in age to FGMS students, while not as likely to waste time socializing. Some supervision would still be required during this type of program.

WPI students currently volunteer as tutors for local students through the EPIC program, in which a college student is matched with a middle school student as a tutor/mentor. Of the 14 parents contacted, only one parent indicated that s/he was aware of this program. All parents, however, fully supported the idea of local college volunteers working with their children, stating that students would be more likely to respond to someone closer to their own age. In return for their time, the college students could be given community service hours or course credits. This would come at no cost to FGMS, who would only be responsible for providing a workspace and notifying parents of the available tutors. This can also be applied to other subjects, as the college student population in the City of Worcester covers many areas of study. This program could also be extended to include a mentoring opportunity, especially for female and minority students. College students could act as role models by bringing local students to their campuses and allowing students who show interest to tour lab facilities or attend classes in a type of shadowing program.

Two days per week, on Tuesdays and Thursdays, homeroom at FGMS is extended into an activity period. This is designed to allow clusters to provide extra help for students or develop activities to be done by the entire cluster. Parents suggested that during this time, teachers organize homework groups in which students work together to complete assignments. Teachers could select students with complementary strong and weak areas, allowing students to teach each other. This would teach valuable teamwork skills. Again, this could lead to "social hour" without adequate supervision. Students may also be inclined to copy each other's work without learning the intended material.

This may also provide an opportunity for less dedicated students to avoid doing homework at home.

In order to address the students' apparent lack of comprehension of the language of mathematics on both open response questions and problems using math-specific terms and symbols, we recommend that teachers include in their lesson plan activities and problems that reinforce vocabulary skills. A possible method could be the use of vocabulary sections on tests and quizzes or worksheets that relate mathematical symbols to the corresponding words. For example, a problem such as:

Match the number with the appropriate vocabulary word.

$1\frac{2}{3}$

*numerator*_____ *denominator*_____ *whole number*_____

would reinforce a student's ability to identify the numerator (2), denominator (3), and whole number (1). Problems such as these could also be designed in the opposite way, for example "Set up a mixed number using 1 as the whole number, 2 as the numerator, and 3 as the denominator." This type of exercise strengthens a student's understanding of mathematics terminology necessary for solving more complicated word problems such as those used as open-response items on the MCAS exams.

A final recommendation would be a review of how students are recommended for and select courses. There is currently very little dialog between teachers and parents regarding reasons for placing a student in a particular ability level. Parents only tend to contact the school if they strongly disagree with the teacher's recommendation. This recommendation often seems to come as a surprise if a parent feels their child is performing well, but is then recommended for a lower ability level than expected. An interaction between teacher and parent should occur much sooner in the school year than

the point of course selection in March or April, when it may be too late to improve. Also, if a teacher makes recommendations based on a certain set of guidelines, these must be consistent with the guidelines enforced by DHS.

5.3 Limitations

Although our study was performed to the fullest extent allowed within the time frame, restraints on time and resources led to several limitations in our research. Our project will provide recommendations for improvements to mathematics programs at FGMS. These recommendations could be implemented by either the staff of the school or future Interactive Qualifying Project (IQP) teams from WPI. They cannot, however, be readily applied to other schools, as they are very specific to the structure, population and requirements of FGMS.

Ideally, the IQP team developing the recommendations should also be involved in their implementation. By being in the school environment for the duration of our project, we have acquired a number of tips and skills useful for interacting with students at this age. These skills are not easily documented for future groups, as they include adjustments to speaking styles appropriate to middle school students. We have also worked extensively with the staff of FGMS, developing working relationships, and our recommendations would be better received if we were to implement them.

The parent sample used in our focus groups and phone survey may be biased. Nearly 200 non-engineering parents were invited to the focus groups, yet only one attended. Only seven more were willing to participate in our telephone survey. The response for engineering parents were much higher, as six of the 20 invited came to the group. All 14 parents who completed our survey indicated that they actively encouraged

their children to excel in math and that they felt a strong background in math would benefit their children's future. However, nearly half (43%) of the students surveyed indicated that they did not have someone close to them who encouraged them to develop their math skills. This could mean that only parents who take an active interest in their child's education were willing to participate in our study. Although the parents invited to the groups and called for the telephone survey were randomly selected, a bias may have been incurred as parents were given the option of whether or not to participate.

Our analysis of MCAS data was limited by changes to the exam and grading formats between the 2000 and 2001 exams. Specifically, scaling was redesigned, making scores between years incomparable. This eliminates the possibility of determining whether improvement efforts by the school were effective, as one cannot see if scores improved between years. Without individual test scores, it is difficult to pinpoint reasons why students chose incorrect answer choices or left test items blank. Also, because gender and ethnic breakdowns by question were not available, it was impossible to find whether certain groups performed better on specific question types or subject areas. Future IQP teams with the benefit of test scores from multiple years would be better able to find correlations between variables.

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Appendix A. Parent Newsletter

Dear Parent/Guardian of F.G.M.S. student:

We are Worcester Polytechnic Institute students conducting a research project here at Forest Grove Middle School. The members of our group are Paulina Ciccone, Amanda Smith and Denny Yee. We are currently researching methods on how to improve student interest and success in mathematics at Forest Grove Middle School and our research intends to provide insight into why young people choose to pursue advance level mathematics classes in middle/high school.

To accomplish this goal we need your assistance. We will be holding a series of focus groups to gather more information for our project. Due to the large population of the school, we will be randomly selecting parents to contact regarding these focus groups. In the coming week some parents will be contacted either by mail or phone. Your participation will be very beneficial to mathematics programs at Forest Grove. All responses will remain completely anonymous, and participation is completely voluntary.

We thank you in advanced for your cooperation and look forward to meeting those selected.

Sincerely yours,
Paulina Ciccone,
Amanda Smith,
and Denny Yee

Appendix B. Student Survey

Please DO NOT write your name!
(Please Check One)

1. Current Grade: ____ 7th ____ 8th

2. Gender: ____ Male ____Female

3. My main ethnicity is (please choose one):

_____ Black, African, African American _____ Hispanic, Latino(a)

_____ Pacific Islander _____ Mexican-American or Chicano

_____ American Indian, Native American _____ White, Caucasian, European

_____ Asian, Asian-American (please specify country/countries)_____

_____ Other (please specify) _____

4. What do your parents do for work? (please specify):

Mother: _____

Father: _____

Please choose one:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5. I feel comfortable raising my hand in math class.	5	4	3	2	1
6. I feel knowing math will help me get a good job.	5	4	3	2	1
7. I give my best effort in math class.	5	4	3	2	1
8. Learning math will be important for my future.	5	4	3	2	1
9. Math is difficult.	5	4	3	2	1
10. My teacher uses activities that make math fun.	5	4	3	2	1
11. Someone close to me encourages me to develop my math skills.	5	4	3	2	1
12. I have someone who motivates me to do well in math.	5	4	3	2	1

13. My current class level in math is: ____ Honors ____ Level 1 ____ Level 2

14. My grade last term in math was: ____ A ____B ____ C ____ D ____ F

15. How often do your parents help you with your math homework?

____ Every day ____ 3-4 times per week ____ 1-2 times per week ____ Never

16. I have heard about the following programs (Please check all that apply):

____ MCAS after school/vacation tutoring

____ Tutoring with WPI students

____ Mentoring Program

____ Pre-Engineering cluster

17. Have you ever attended after-school programs for math help? ___Yes ___No

If yes: a. Who helped you?

____My math teacher ____ Another teacher ____ Math tutor ____ Other _____

b. Do you feel it helped you understand math better? ___Yes ___ No

Appendix C. Focus Group Invitation Letter-Non-Engineering Parents

Dear Parent/Guardian of F.G.M.S. student:

My name is Amanda Smith and I am writing on behalf of my Worcester Community Project Center research team from Worcester Polytechnic Institute. We are currently researching methods on how to improve student interest and success in mathematics at Forest Grove Middle School and our research intends to provide insight into why young people choose to pursue advanced level mathematics classes in middle/high school.

To accomplish this goal we need your assistance. We will be holding two focus groups at which parents can voice their opinions on current mathematics programs at Forest Grove Middle School. Participants will also be given the opportunity to provide suggestions on how to achieve this goal. Your participation will be very beneficial to mathematics programs at Forest Grove. Your responses will remain completely anonymous, and participation is completely voluntary.

These groups will be held in the Taylor Room on the lower level of the Campus Center of Worcester Polytechnic Institute on Tuesday, April 2, 2002 and Wednesday, April 3, 2002 at 6:30 PM and should take no longer than one hour of your time. For attending, you will receive an entry into a raffle for a $25 gift certificate to a local supermarket. Refreshments will also be provided. To confirm your attendance, we ask that you return the lower portion of this letter to your child's math teacher by Thursday, March 28, 2002.

Thank you in advance for your cooperation with this study.

Sincerely,

Amanda Smith
Worcester Community Project Center
Class of 2003

I would like to attend the focus group on (Choose One):

____ Tuesday, April 2, 2002 ____ Wednesday, April 3, 2002

Name: _____

Signature:_____

Date:_____

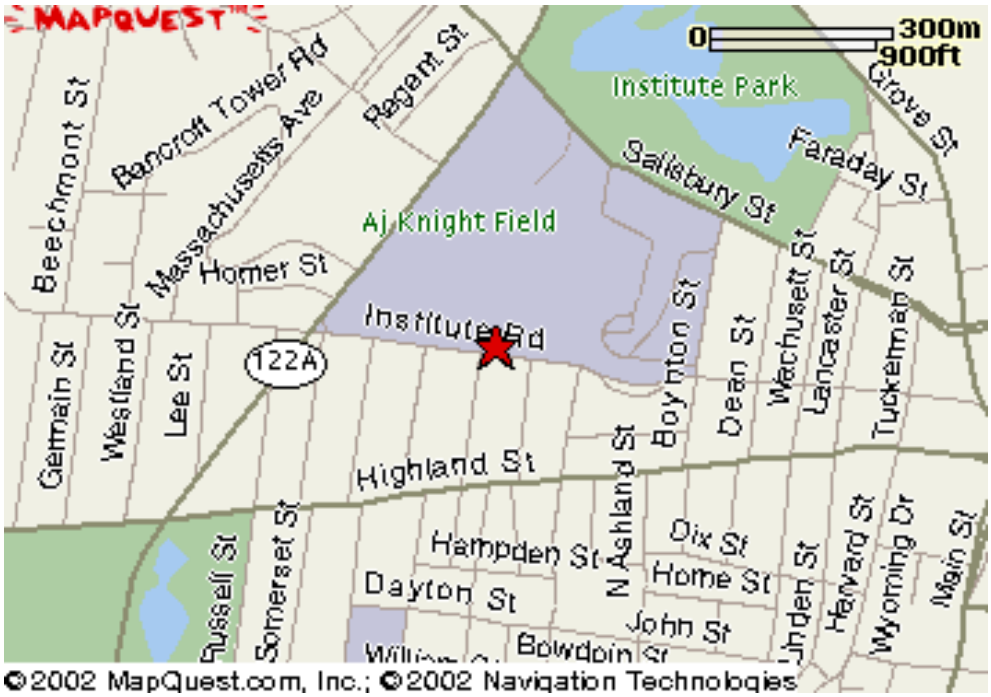
Appendix D. Reminder Card for Focus Group

REMINDER!!!

Just a reminder that the focus group regarding Forest Grove Middle School mathematics programs will be held tonight, Tuesday, April 2, 2002, at 6:30 PM in the Taylor Room on the lower level of the Campus Center of the WPI Campus.

Directions:

From Park Ave.: Turn down Institute Rd. between the WPI Football Field and the Mobil station. Take a left onto West St. at the first stop sign. Bear left at the top into the main parking lot. Park in visitor parking and follow signs between Alumni Gym and Higgins Labs to the Campus Center, a large glass-fronted building.



Appendix E. Parent Focus Group Survey

In order to maintain anonymity we will not ask for your signature, but returning this completed survey will serve as your consent that you are willing to participate in our research.

1. Gender: ____Male ____Female
2. My ethnicity is (please check all that apply):

_____ Black, African, African American _____ Hispanic, Latino(a)

_____ Pacific Islander _____ Mexican-American or Chicano

_____ American Indian, Native American _____ White, Caucasian, European

_____ Asian, Asian-American (please specify country/countries)_____

_____ Other (please specify)_____

3. How many children do you have attending Forest Grove Middle School? _____
4. What is/are the gender(s) of your child/children that attend FGMS? (Please indicate number of children of each gender) ____Male ____Female
5. Do you have access to the internet? ____ Yes ____ No
6. Your level of education:

____ Some high school

____ GED/Diploma

____ Some college

____ College degree

____ MS or higher

7. What is your occupation?_____

8. What hours do you normally work: (check all that apply)

____Days ____Evenings ____Nights

9. How often do you help your children with homework?

____Every day ____3-4 times per week ____ 1-2 times per week ____Never

10. Have any of your children ever attended any kind of math help at Forest Grove?

____ Yes ____ No

a. If so, what kind? _____

b. Do you feel it helped them improve their grade? ____ Yes ____No

11. Do you seek outside assistance, such as a private tutor, to help your child in math?

____ Yes ____ No If so, what kind? _____

12. I am aware of the following programs available to my child: (Please check all that apply):

____ MCAS after school/vacation tutoring

____ Tutoring with WPI students

____ Mentoring Program

____ Technology/Engineering cluster

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13. I am knowledgeable about the Technology/Engineering Cluster at Forest Grove Middle School.	5	4	3	2	1
14. I actively encourage my child to excel in math.	5	4	3	2	1
15. I feel that a strong background in math will benefit my child in the future.	5	4	3	2	1
16. I am comfortable working with my child on his/her math homework.	5	4	3	2	1

17. I feel Forest Grove Middle School is truly concerned about my child's success in math.	5	4	3	2	1
18. I feel the Technology Cluster is a good opportunity for my child.	5	4	3	2	1

19. Using the suggestions listed on the board, please choose five which you feel would be most useful to you/your child and rank them from 1 (most useful) to 5 (less useful).

1. _____
2. _____
3. _____
4. _____
5. _____

Appendix F. Thank You Letter

Dear Mr./Ms. _____,

We would like to personally thank you for your attendance at our focus group on Thursday, April 4. We thought the group was very successful. Your participation helped us to produce a list of great ideas for improving mathematics programs at Forest Grove Middle School. These suggestions will be truly beneficial to current and future students.

The top five suggestions that will be brought directly to Principal Kelley are:

1. Parent guides/meetings for helping with homework.
2. Better/more personal communication between teachers and parents.
3. Peer/honors tutors.
4. Local college volunteers tutoring FGMS students.
5. Organizing homework groups where students work together.

All suggestions that came from our discussion will be included for further review in our final report. If you are interested, a printed copy of this report will be available at FGMS. Electronic CD-ROM copies are available upon request.

Thank you again for your assistance with our project. Congratulations to the winner of the $25 gift certificate to Santiago's Plaza, Ms. Carolyn Maloney. If you have any further suggestions, or to request an electronic copy of our report, we can be reached through April 30th by contacting FGMS.

Sincerely,

Appendix G. Teacher Interview Questions

1. How long have you been teaching?
2. Have you taught any other subjects?
3. Have you taught any other grade levels?
4. How many students do you have?
5. What is the racial/gender make-up of your classes?
6. Do you see trends with certain groups of students being more likely to volunteer in class?
7. If so, how do you address this?
8. Do you have any special techniques for gaining students' attention?
9. How do you encourage students to volunteer answers in class?
10. Do you think randomly calling on students helps to keep their attention?
11. What kinds/how much homework do you assign?
12. Do you offer outside help for your students?
13. How do you normally communicate with parents?
14. What kind of a response do you seem to get from parents?
15. Have you found that certain types of activities seem to involve more students?
16. Do you have any suggestions for how students can be motivated to succeed in math?

Appendix H. Parent Phone Survey

H.1 Script for Introducing Phone Survey

Hi, my name is _____ and I'm a WPI student working with the Forest Grove Math teachers to complete a graduation requirement. As one of our project goals, we would like to speak with parents and gain feedback and suggestions for improving math programs at Forest Grove. I was wondering if you would be willing to take a short survey over the phone. It shouldn't take more than five minutes of your time, and your answers will be very beneficial to the students at Forest Grove.

THANK YOU
If you think of any further suggestions, I can be reached by contacting the main office at Forest Grove.

H.2 Phone Survey

1. Gender: ____Male ____Female
2. My ethnicity is (please check all that apply):

_____ Black, African, African American _____ Hispanic, Latino(a)

_____ Pacific Islander _____ Mexican-American or Chicano

_____ American Indian, Native American _____ White, Caucasian, European

_____ Asian, Asian-American (please specify country/countries)_____

_____ Other (please specify)_____

3. How many children do you have attending Forest Grove Middle School? _____
4. What is/are the gender(s) of your child/children that attend FGMS? (Please indicate number of children of each gender) ____Male ____Female
5. Do you have access to the internet? ____ Yes ____ No
6. Your level of education:

____ Some high school

____ GED/Diploma

____ Some college

____ College degree

____ MS or higher

7. What is your occupation?_____

8. What hours do you normally work: (check all that apply)

____Days ____Evenings ____Nights

9. How often do you help your children with homework?

____Every day ____3-4 times per week ____ 1-2 times per week ____Never

10. Have any of your children ever attended any kind of math help at Forest Grove?

____ Yes ____ No

c. If so, what kind? _____

d. Do you feel it helped them improve their grade? ____ Yes ____No

11. Do you seek outside assistance, such as a private tutor, to help your child in math?

____ Yes ____ No If so, what kind? _____

12. I am aware of the following programs available to my child: (Please check all that apply):

____ MCAS after school/vacation tutoring

____ Tutoring with WPI students

____ Mentoring Program

____ Technology/Engineering cluster

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13. I am knowledgeable about the Technology/Engineering Cluster at Forest Grove Middle School.	5	4	3	2	1
14. I actively encourage my child to excel in math.	5	4	3	2	1
15. I feel that a strong background in math will benefit my child in the future.	5	4	3	2	1
16. I am comfortable working with my child on his/her math homework.	5	4	3	2	1

17. I feel Forest Grove Middle School is truly concerned about my child's success in math.	5	4	3	2	1
18. I feel the Technology Cluster is a good opportunity for my child.	5	4	3	2	1

19. The following suggestions were made by parents. Do you think they would be useful to you or your child?

1. Parent guides/meetings on how to help with homework. ____Yes ____ No
2. Better/more personal communication between teachers and parents. ____Yes ____No
3. Peer/honors tutoring. ____Yes ____No
4. Local college volunteers tutoring FG students. ____Yes ____No
5. Organizing homework groups where students work together. ____Yes ____No

Appendix I. Focus Group Brainstorm Worksheet

Please write your initial reactions to the following. These sheets will only be used to initiate discussion.

1. Current math programs at Forest Grove Middle School. How do you feel about the programs that are currently offered? How can they be improved?

2. Availability of outside help in math. Is enough help available? Do you feel the school makes an effort to keep parents aware of outside help?

3. Communication with teachers. Is communication between parents and teachers generally a positive experience? Is there something they could do better?

4. Please list any other suggestions or concerns you may have regarding the quality of mathematics at FGMS.

Appendix J. List of Suggestions from Focus Groups

Suggestions (Points)

1. Parent homework guides (15).
2. Better communication between parents and teachers (14).
3. Peer/honors tutoring (9).
4. College volunteers for tutoring (8).
5. Tie: Homework groups (7) and meetings (7).
7. Step-by-step homework help (6).
8. Parent volunteers (5).
9. Tie: CD-Rom supplements to books (3) and Parent-Teacher Association (PTA) (3).
11. Requiring parent signatures for all documents (2).
12. Video recordings of teachers teaching a class (1).