EDITORIAL

It has been 10 years since the Colloquium was launched, and with this issue the Journal completes its 9th year of publication. By all accounts, the Colloquium and the Journal have carved out a place for themselves in the Graduate School of Education.

The Colloquium Journal creates an opportunity for graduate students to share their completed research ideas or research in progress. Nowadays, serious attention is paid to the improvement of research in education. “Scientifically-based research” or scientific inquiry has been a major debate at the conferences and a favorite topic of the research journals. A committee of the National Research Council (2002) examined the status and quality of research in education and produced a report that outlines some critical features of scientifically reliable research and several design principles to guide the creation of an advanced educational research enterprise.

Scientific inquiry in education is one of the forms of viewing and describing reality. It is a way of knowing and understanding of an ever changing educational system, which is a very complex social construct.

It is a continual process of rigorous reasoning supported by strong association between methods, theories, and findings, which influence curricula and policy. Schooling cannot be improved by relying on just folk wisdom about student learning and how schools can be organized. It is unlikely that someone would propose a new medical breakthrough without multiple studies of its effect. Likewise, one should not expect to improve education without reliable research. For that reason, there will be always a great demand for rigorous, sustained, scientific research to reengineer the schools in effective ways.

We belong to the community of educators who are constantly trying to learn, understand and improve educational processes. We make professional decisions that have both immediate and long-range effects on others: students, teachers, parents, and ultimately our communities. When conducting research we discuss theoretical and practical views of the real world, and ideology and ethics as they shape and form research in education. We equally value and apply quantitative and qualitative sources of data, and carefully select the appropriate methods of inquiry. The better knowledge of making inquiries we have the better producers and consumers of educational research we are.

The major questions we always pose are to what degree our explanations of phenomena match the realities of the world and whether the research findings are valid and reliable. We make every effort for continuous verification of our conjectures and conclusions, and look for new lines of inquiry that would provide more definitive answers to the questions we will address over time.

In this issue I am pleased to present several articles that demonstrate our graduate students’ research endeavor.

Marsha Pease is concerned with the high failure rates in community college remedial mathematics classes. Searching for the roots of the problem in research literature and analyzing her own experience, she hypothesized that insufficient or no attention to homework is one of them. In the paper she discusses the purposes of homework and homework policies as well as the research on the relationship between homework and student achievement.

Jeff Todd had been involved in the Middle School Mathematics Initiative professional development program sponsored by the Massachusetts Department of Education. He participated in the development of the instrument, Lesson Plan Evaluation Rubric (LPER), and collected quite extensive data to conduct factor analysis of the items of the instrument that will be used further to investigate the relationship of teachers’ written lesson plans to student mathematics achievement.

Emile Tabea describes his study that examined low-income, ethnic, and racial minority parents’ attitudes toward school voucher programs. He conducted focus group interviews with 31 low-income Asian, African, African American, and Latino parents and found that they hold fairly positive views about the public schools their children attend, although they indicated that these schools need improvement in a number of areas. Based on the findings of this study, he offers some recommendations to make public schools attractive to all low-income, ethnic, and racial minority parents.

Brad Allen, our devoted and consistent correspondent, presents an interesting report on how to use algebra and trigonometry to model plant growth. He suggests the use of graphics software packages such as Maple and Matlab to develop and analyze the models that may be used in a high school or college mathematics course to help students understand how basic assumptions about plant growth lead to the Golden Ratio and accurate plant-growth simulations.

I am deeply grateful to all contributors to this issues and invite all to submit papers to the next volume of the journal.

Regina M. Panasuk
GUIDELINES FOR SUBMISSION

The papers submitted for the Journal must discuss psychological and pedagogical issues and trends related to mathematics and science education.

WHEN SUBMITTING A PAPER, PLEASE USE THE FOLLOWING GUIDELINES:

1. Submit an electronic version of the paper and one hard copy, an abstract, approximately 150 words, and a biographical sketch, about 30 words. All pictures and diagrams must be submitted in a separate document.

2. Use double spacing with one-inch margins.

3. For references, tables, and figures follow the style described in the Publication Manual of the American Psychological Association (APA), Fifth Edition.

4. Paper length should not exceed 30 pages, including pictures, tables, figures, and list of references.

5. Paper must be received by November 15.

6. Authors will be notified about the status of their papers by January 15.

7. The Colloquium is scheduled in April.

SUGGESTIONS TO THE AUTHORS:

When preparing a research paper include:

a) a rationale and an identification of the research question(s)

b) a conceptual framework or brief statement of relationship to the literature

c) an identification of research methodology

d) a summary of the analytical technique(s)

e) a summary of preliminary findings

f) conclusions and discussion

SUBMIT PAPERS AND CORRESPONDENCE TO:

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Bradford Allen is a chair of the mathematics department at Lasell College, MA. He received his Ed.D. in Math and Science Education in 1998 from UML.

Marsha Pease teaches mathematics at North Shore Community College. She also develops curriculum for and teaches MCAS preparation classes. Currently she is working on her dissertation proposal.

Emile Tabea is a part-time faculty in the Department of Sociology at the University of Massachusetts Lowell. He defended his dissertation in Educational Leadership in 2002. His research interest is the impact of globalization of education.

Jeffrey Todd is a seventh grade mathematics teacher at the Daley Middle School, Lowell. He is working on his dissertation.

2004-2005 Academic Year

Dissertation Defense Stage

Suellen Robinson
Volition and Its Relationship to Retention in Community College Mathematics Classes

Adele Miller
An Investigation of College Students’ Rational Number Sense in the Developmental Mathematics Classroom

Jeff Todd
Middle School Mathematics Teachers’ Use of Systematic Lesson Planning and Its Relationship to Student Mathematics Achievement in Low-Performing Urban Middle Schools

Rocco Perla
The Development and Validation of a Case Study in Science in the Context of a Non-Linear Model of Scientific Change

Scott Stanley
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Kathy Shea
Mentoring Alternatively and Traditionally Licensed First Year Science Teachers

Dissertation Proposal Stage

Danielle Cross
Exploring the Relationship Between Pre-Service Teachers’ Level of Knowledge in Mathematics History and Beliefs About Mathematics

Marsha Pease
Factors Affecting Mathematics Homework Completion and Achievement in Community College Remedial Mathematics Students

Qualifying Paper Stage

Jessica Devonis
Kate McLaughlin
Alex Ballantyne
Peggy LaBrosse
Velerie Finnerty
John Boucher
Michael Doherty
Chester Orban
ABSTRACT

The purpose of this paper is to review the body of research that advances understanding of the relationship of homework and achievement of the community college students in the remedial mathematics classes. One of the reasons for the high failure rates of students in community college remedial mathematics classes is disregard to homework. Although educators intuitively believe that there is a relationship between the completion of mathematics homework and achievement in mathematics, there is no consensus in the research to support this belief. This paper discusses the purposes of homework and homework policies as well as the research on the relationship between homework and student achievement. Research includes the effects of homework versus no homework, time spent on homework, amount of homework completed, and feedback on homework. Recognizing that student actions follow student beliefs, a discussion of student beliefs and attitudes towards mathematics homework is also provided.

INTRODUCTION

Over the past 20 years, there has been an increase in the number of remedial mathematics classes offered in community and four-year colleges and universities across the country (Haycock, 2002; Waycaster, 2001). Remedial, sometimes referred to as developmental, mathematics classes are designed to provide students with the mathematics concepts and skills required for success in college level mathematics courses and usually consist of basic mathematics topics (Education Commission of the States [ECS], 2002). Table 1 shows course descriptions excerpted from the Rio Hondo Community College Schedule of Classes (2003). These courses are representative of the remedial mathematics courses offered in at least three community colleges in Massachusetts (North Shore Community College, 2004; Northern Essex Community College, 2004; Quinsigamond Community College, 2004).

<table>
<thead>
<tr>
<th>Course and Course Number</th>
<th>Course Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Mathematics – Course 020</td>
<td>Operations with whole numbers and fractions, operations with decimals and percentage problems.</td>
</tr>
<tr>
<td>PreAlgebra – Course 030</td>
<td>Introduction to equations, order of operations</td>
</tr>
<tr>
<td>Elementary Algebra – Course 050</td>
<td>Operations with integers, exponents and first-degree equations, operations with polynomials, factoring, solving quadratic equations by factoring and applications. Linear equations, slopes, systems of equations and operations with fractional expressions. Operations with radical expressions, quadratic equations and inequalities.</td>
</tr>
<tr>
<td>Intermediate Algebra – Course 070</td>
<td>Linear and quadratic equations and inequalities, systems of linear equations, polynomials, exponents and radicals, relations and functions, graphs, exponential and logarithmic expressions.</td>
</tr>
</tbody>
</table>

Table 1. Representative Community College Remedial Mathematics Courses

According to the National Council of Teachers of Mathematics (2000), basic mathematics topics are introduced in grades 3 to 5, Pre-algebra is introduced in grades 6 to 8, and elementary and intermediate Algebra are introduced in grades 6 to 12. In recent years algebra topics have been introduced into grades 7 and 8 mathematics curricula, with more Pre-algebra topics being introduced in the elementary grades (Davies, 1988). In the community college classroom the course material that is supposed to be studied over six to nine years in elementary, middle and high school is condensed to four or five classes.

When new students register for classes in the community college system in the United States, they are tested for reading, writing and mathematics proficiency (ECS, 2002). According to the Education Commission of the States (2002), there is no consistency amongst community colleges as to how deficiencies are remedied. For example, in 21 states, if test results indicate that reading, mathematics and/or writing skills are deficient, students are placed into and are required to pass remedial reading, writing and/or mathematics classes. Yet in California, Maine, and South Carolina, the test
results are advisory and students are not required to take remedial courses.

Sagher and Siadat reported in 1997 that a national study conducted by the U.S. Department of Education found that 21% of all college freshmen were enrolled in a remedial mathematics class. In 2002, Haycock stated that more than 90% of all mathematics enrollments in higher education were in courses including curriculum taught in high school.

Waycaster (2001) and Haycock (2002) suggested that in order to prepare students to take college-level mathematics classes, community and four-year colleges, and universities all around the country have to introduce and/or increase the number of remedial or developmental mathematics classes offered at their institutions.

Investigating the nature of the high level of failure in the remedial classes, Sagher and Siadat (1997) and Kralovec and Buell (2000) found that the most common behavior pattern of unsuccessful students is disregarding homework. The following is a discussion of historical perspectives of homework and the research studies about homework focused on different aspects such as purpose, policy, types, amounts, and forms of feedback.

HOMEWORK

HISTORICAL PERSPECTIVE

Over the years there has been controversy about the benefits of homework. Kralovec and Buell (2000) described the nature of schooling in the early nineteenth century. Student attendance in primary school was unpredictable and the school year was short. Teachers in rural locations taught all subjects to students whose ages ranged from 6 to 20. In urban schools, classrooms were crowded and understaffed. Education focused on reading, writing and arithmetic. By grade five, large numbers of students left school for work either on farms or in factories. Only a small number of students stayed beyond grade five. Those students who stayed in school studied history, geography, literature, and mathematics. Learning consisted of drill and memorization and recitation. Scholars do not indicate about homework practices. By the late nineteenth century, the majority of Americans had migrated to the city and many, including children, worked long hours in the factories. By 1880 there was considerable pressure on schools to abolish homework. Parents believed that homework caused illness because students did not have enough time to play outside. There were also doubts about the educational value of homework along with the belief that homework was a threat to the emotional, physical and mental health of the child (Kralovec & Buell, 2000).

Anti-homework movements continued into the first half of the 20th century. Dacie (1935) said that homework was to blame for the current generation of “undernourished, nervous, bespectacled, round shouldered children” (p.22).

The 1957 launch of Sputnik changed the nation’s discussion about the importance and role of homework. By 1961, educators and some parents advocated increasing amounts of homework since homework was now seen as the primary means of increasing academic achievement, although there was no research to support that idea (Kralovec & Buell, 2000). Kralovec and Buell (2000) argued that some newspapers and women’s magazines still suggested that children were too tired to do homework after a full day of school activities.

In 1966, the National Education Association developed guidelines suggesting that teachers should assign no homework for early elementary students, that teachers should not assign more than one hour of homework per day for upper elementary and junior high school students, and that teachers should not assign high school students more than one and one half hours of homework per day. The association also stated that homework should not be assigned more than four nights per week for any students.

HOMEWORK POLICY IN K--12

Even though currently homework is widely viewed as the means to reinforce and strengthen concepts and skills and extend teaching and learning opportunities, school districts and departments either do not provide at all or have specific directions for homework quantity or content. Consequently homework quantity and content policies are quite diverse across the schools. The Los Angeles Unified School District (1990) homework policy provides general guidelines for
assigning homework that suggest that, “homework for all students should be purposeful and clear and should be based on the needs of the class” (p. 24) but allow wide latitude for interpretation by administrators and teachers.

Murphy and Decker (1989) conducted a descriptive study on several aspects of how high school teachers use homework. They collected replies to questions related to district, school and department policies about homework and homework enforcement, the purposes, types and frequency of homework assignments, homework grading practices, and homework completion rates. Their sample consisted of 2,986 people across rural, suburban and urban public schools in Illinois. Fifteen percent of the teachers were mathematics teachers, with no indication as to grade or track (advanced placement, college preparation, general, vocational, or special education).

Murphy and Decker (1989) found that, when district and schools have no established homework policies, “teachers operate in a vacuum” (p. 263) and that decisions on homework “are established by default by class participants” (p. 263). However, they found that even with no established policies, 86% of the teachers of their sample of approximately 800 teachers assigned homework. They also investigated whether homework was assigned in an equitable fashion across tracks (advanced placement, college preparatory, vocational, general and special education). They found that 77% of the vocational classes, 83% of the general classes and 79% of the special education classes were given homework to be completed in class, while 98% of the college preparatory and advanced placement classes were assigned homework to be completed outside the classroom. The researchers suggest that this is an inequitable pattern because it places students in nonacademic streams at a disadvantage with their peers in academic tracks. Teachers, who did not assign homework to be completed outside of class, provided classroom time for completion of homework. The researchers found it difficult to justify the regular assignment of homework to be completed in class. “This practice defeats a major function of homework, to extend the opportunity to learn by providing additional work time” (Murphy & Decker, 1989, p. 264).

Murphy and Decker (1989) classifying the types of homework assignments found that 50% represent textbook problems and questions, 25% represent worksheets, with the remainder of choices being essays and writing assignments, reading and research reports, independent projects, watching television programs, and other. The researchers observed that the types of assignments most likely to reflect higher order cognitive skills— essays, writing assignments, reading, and research— were given infrequently. Of course, such types of assignments would require teachers to adequately prepare and assess more complex types of homework.

**HOMEWORK POLICY IN COLLEGE**

Community and four-year colleges and universities assume that faculty members will assign homework and that college students will do homework. This assumption is corroborated by a review of college handbooks available online which state the expectations that students will attend classes and complete homework assignments. For example, the Pierce College (Pierce College, 2003) policy is that two to three hours of homework are expected for each class hour. Heublein (2003) studied college mathematics class syllabi and found that most of them state the expectations that students will complete all assigned homework.

**PURPOSE OF HOMEWORK**

Cooper (1989) defines homework as work assigned by the teacher that is to be completed outside of the normal class period or during non-school hours. Langdon and Stout (1969) claim that homework provides the drill that reinforces classroom learning and that the ideas, facts, skills, and procedures opened up to the student during the day “become more firmly rooted and more securely established” (p. 16). They say, “drill and practice are essential to reinforce learning, and homework – wisely devised – provides a means” (p. 17). Thorndike (1926) emphasized the importance of practice to form bonds between concepts. He stressed the dangers of too much practice (overlearning) as well as too little practice (underlearning). “The amount of practice should always be considered in the light of its interest and appeal to the
pupil’s tendency to work with full power and zeal” (p. 137).

Cooper (2001) summarizes the purposes of homework in four categories: practice and review, preparation for future assignments, extension (transfer of previously learned skills to new situations) and skill integration requiring the student to apply many separately learned skills to a single product. Langdon and Stout (1969) say that homework can extend the “teaching opportunity” (p. 14).

Well-structured homework assignments increase the amount of time available for learning and extending content coverage (Pennsylvania State Department of Education, 1985). In addition, homework can fulfill other educational functions, such as developing independent work habits, encouraging responsibility, refining study skills, and providing opportunities for creativity. However, Kralovec and Buell (2000) suggest that beliefs that homework teaches self-discipline, develops initiative and responsibility, and increases achievement are “dubious at best” (p. 39).

Murphy and Decker (1989) found that homework was not assigned for a wide variety of purposes. Three reasons accounted for approximately 90% of the responses. Fifty-five percent of the respondents said that the most common purpose of homework was to reinforce class material, to review concepts and skills introduced in class. Twenty-three percent of the respondents said that mastery of course objectives was the second most common purpose, and 11% of the respondents said that the introduction of new material was the purpose of homework.

**HOMEWORK AND STUDENT ACHIEVEMENT**

**HOMEWORK VERSUS NO HOMEWORK**

In order to explore the anecdotal evidence that homework has little or no value, Teahan (1935) conducted one of the first studies to compare the effects of homework with no homework on student achievement. Her sample consisted of sixth grade arithmetic students in two randomly assigned classes. Standardized tests determined that there was no significant difference between the two classes.

For an eight-week period, the teacher of the treatment group assigned three 20-minute homework assignments per week and the control class received no homework. Both classes received similar instruction during the classroom period. The teachers taught addition and subtraction during the first four-week period and switched classes to teach multiplication and division for the next four-week period, so students in both classes were exposed to both teaching styles.

In the treatment class, the homework was corrected and given back to the students. The post-test, an achievement test developed by the researcher, was based on classroom work. Teahan (1935) found that at the end of the eight-week period, there was no significant difference in terms of achievement between the two classes. The researcher conducted individual interviews with 40 students, 20 students at the end of each four-week period. She found that their responses to computation problems were “identical” and that no students “seemed to have much understanding of underlying concepts” (p. 45).

Teahan (1935) acknowledged limitations in the study and suggested that future research should include the effects of homework assigned five days a week, not just three days a week. She also suggested that homework assignments should reflect an appropriate number of problems to reflect drill on appropriate topics rather than time (20 minutes).

To further explore the discussion about the efficacy of homework and in reaction to Teahan’s (1935) study, Anderson (1946) conducted a study to determine the effects of homework upon scholastic success. His sample consisted of 58 eighth-grade students in two classes. One class was designated the treatment group, the home study group, and the other class was designated the control group. Both classes had the same teachers in three subjects, English, social studies and mathematics; that is, the same teacher taught both English classes, another teacher taught both social studies classes and a third teacher taught both mathematics classes. The materials used in the classes were exactly the same as were the teaching techniques. In the home study group, students were given assignment sheets to be studied and directions for study. Students in the control
group were not instructed to do any schoolwork outside of the classroom.

Based on the averages of five unit tests in each subject, Anderson (1946) found that there was a significant difference between the test scores of the home study group and the control group. For example, on the first test students in the control group had a mean score of 64 and the students in the treatment group had a mean score of 78 and, on the fifth and final test, students in the control group had a mean score of 74 while students in the treatment group had a mean score of 90. A breakdown of the scores on the unit tests revealed that the students in the home study group maintained proportionately the same level of achievement in English, mathematics and social studies. Students in the control group showed varying levels of achievement in the three subjects, in some instances very high and in others very low.

Teacher comments indicated that students in the home study group had a “better sense of direction” (p. 143) in the classroom and were able to work with much less teacher input than were students in the control group. Anderson (1946) concludes that home study, assigned and properly evaluated, is a means to improving scholarship. He found that the brighter students in the control group did not gain as much comparing to those in the home study group. He also found that the average and “dull” (p. 143) students in the control group were much less successful than those in the home study group. Unfortunately, this research does not show results on a subject-by-subject basis.

Cartledge and Sasser (1981) conducted a study to determine whether significant differences existed between the mathematics’ achievement of college students who were assigned and who were not assigned to homework. The sample consisted of 30 volunteer students in two Algebra classes at Troy State University, Fort Benning, Georgia. The students were primarily active duty and retired enlisted military Caucasians with an average age of 32 years. They had completed an average of one year in college and had a mean grade point average of 2.65. The Algebra course began on April 8, 1981 and continued until June 15, 1981.

The only difference in the instruction provided to the two groups was the weekly assignment of homework to the treatment group. Homework assignments consisted of problems selected from the students’ textbook. The instructor corrected assignments and recorded the grades. It was not explicitly stated, but it appears that the same instructor taught both classes, so we can assume that the teaching techniques were somewhat identical.

The pre- and posttest instrument used to define achievement was developed by the researchers and administered by the classroom instructor. The results show no statistically significant differences in the pretest scores between the two groups. The results for the posttest scores were statistically significant only at the .10 level indicating that students receiving homework assignments were “more likely to learn more” (p. 10) than those not receiving homework assignments. In spite of the weakness of the significance, the researchers conclude that homework may be of benefit and that there is very little evidence that the assignment of homework has a negative effect on achievement.

The results of this Cartledge and Sasser (1981) study are consistent with the results of Anderson’s (1946) study regarding the positive effects of homework. However, confounding variables in the Cartledge and Sasser (1981) study might be the age and motivation of the students. The researchers indicated that the students in both the control and treatment groups received copies of the syllabus indicating which chapters of the textbook would be studied during each class session. Students were also informed which chapters the midterm test and the final examination would cover. The researchers do not determine if the students in the treatment group actually did any homework and review on their own, even though all students volunteered for and understood the conditions of the study.

Weems (1998) studied the effects of homework collection versus no homework collection on student achievement for 108 students enrolled in a developmental intermediate algebra course at a four-year university in western Tennessee. Specifically, she asked if students who are required to hand in homework assignments would perform better than students who are not required to hand in homework assignments. The content in the intermediate Algebra
course in this study corresponds to the content of the remedial intermediate Algebra course shown earlier in the Table 1. Students were placed in this remedial intermediate algebra class based on scores on the college placement examinations.

In both the control and the treatment groups, homework was emphasized, with assignments given at each class meeting. Students in the treatment group had the additional requirement of keeping their homework assignments organized in a notebook. The notebook, graded during each exam, comprised 5% of the overall course grade. Problems were not graded individually, but “holistically” (p. 22) to encourage completion. Students who attempted at least the assigned problems and demonstrated the work received full credit. Homework was not collected in the control group. The study was conducted over two semesters, with approximately one half of the students taking the course in the fall semester and the other half taking the course in the spring semester.

Weems (1998) found that the control and treatment groups differed significantly. The University does not allow the grade of D in remedial classes, so students received grades A, B, C, F or W for withdrawal. A significant difference resulted in the comparison of the number of A’s earned by the students in the two groups. Five students in the control group received A’s while 15 in the treatment group received A’s. However, she found that the results regarding the overall grade distribution were non-conclusive. “A difference exists between the control and experimental groups; however, the individual items leading to the significant difference could not be identified” (p. 24). Yet, it is interesting to note that the percent of students withdrawing in the treatment group was higher (10 students for 18.9%) than in the control group (five students for 9.1%). She speculates that the increased interaction in the treatment group fostered more individual discussion between the student and the instructor. Students may have been more aware of their standing in the course and more likely to choose to begin again in a subsequent semester.

Weems (1998) said, “the instructor interested in experimenting with homework collection should give considerable forethought to the collection guidelines to ease the grading burden” (p. 24). During the study, the instructor employed two different homework collection and correction strategies. During the first semester, student notebooks were collected and holistically graded in class while students were taking tests. It was not possible for the instructor to correct all of the notebooks during one test session and in many cases notebooks were impossible to grade due to the failure of students to follow directions. During the second semester, students were required to place all completed homework assignments in a manila folder, but the researcher does not discuss how and where these assignments were corrected.

This research supports studies conducted by Anderson (1946) and Cartledge and Sasser (1981) that presented evidence that homework has a positive effect upon achievement. Weems (1998) assigned but did not collect and evaluate homework in the control group; for the treatment group she not only assigned homework, but homework was collected, graded and the homework grade was included in the final course grade.

**TIME SPENT ON HOMEWORK**

To further isolate the homework factors which effect student achievement, researchers explored time spent on homework. The Forum of Educational Organization Leaders suggested that the elementary students might benefit from one hour of homework, whereas high school students should complete two or more hours of meaningful homework per night (Kralovec & Buell, 2000). The National Association of Secondary School Principals has recommended 20 to 30 minutes of homework per night per academic course for college-bound students and about half that much time for job-bound students (Science and Mathematics Education Resource Center [SMERC], 1984).

In their research to determine attitudes toward study hall, Blumenfeld and Remmer (1966) found a relationship between homework and achievement. Their sample consisted of 2,000 students, 981 boys and 1019 girls, in grades 10, 11 and 12. The researchers selected their sample from 12,000 students who had participated in a university-sponsored national opinion poll and the researchers determined that their sample was representative of high school students across the country with respect
to race, sex, grade, rural and urban residence and geographic region. The researchers selected six items from the opinion poll related to study halls for their analysis. The items ascertained the number of hours the student spent in study hall, doing homework at school and doing homework outside of school, the degree to which the student thought study hall was the best time and place to study and did their friends think that study hall was the best time and place to study. Students also self-reported grades using a scale of below average, average, above average and excellent. The researchers determined that these self-reports on grades were reliable by correlating them with class ranks.

The researchers found that 75% of the sample spent one hour or less in study hall, with the bulk of their homework being completed outside of school. Fifty-eight percent reported spending less than one hour a day doing homework at school, while 64% reported spending more than an hour a day doing homework outside of school. Forty-nine percent said that study hall was a good place to study, while 47% disagreed. Interestingly, further analysis of the data revealed that less time spent in study hall was associated with better grades. The researcher's found that better students did more homework, but they did so at the time and place of their choosing. Blumenfeld and Remmer (1966) corroborate the research of Anderson (1946), Cartledge and Sasser (1981) and Weems (1998) which determined that there is a relationship between homework completion and student achievement and further state that more homework is associated with better grades.

Keith (1982) researched the effects of homework time on high school seniors’ achievement. His sample consisted of 20,364 high school seniors drawn from the first wave of the National Center for Education Statistics' High School and Beyond (HSB) longitudinal study conducted by the National Opinion Research Center (1980). Data included race, family background, ability, field of study, grades so far in high school and time spent on homework. Keith’s (1982) analysis confirms that an increase in time spent on homework has a positive effect on student grades in high school. The researcher divided the ability variable into three categories, lower 25%, middle 50% and upper 25%. He found that mean grades and homework time have a positive linear relationship for all levels of ability. His analysis confirms Anderson’s (1946) observation about the compensatory effects of study. With one to three hours a week, the average low ability student can achieve grades commensurate with an average ability student who does not do homework.

**Amount of Homework Completed**

In attempts to control other variables, researchers explored the relationships between amount of homework completed and student achievement. Murphy and Decker (1989) found that the majority of teachers (51%) reported that students finished between 81% and 100% of their homework and 30% said that the completion rate was between 61% and 80%. Teachers also reported that 19% of the students completed less than 60% of their homework. The researchers found that while these numbers are better than those reported by other studies, this data reveals that, “many homework assignments are being ignored by high school students” (p 266).

Cooper, Lindsay, Greathouse and Nye (1998) determined that there is a positive relationship between the amount of homework completed and student achievement. Researchers used standardized test scores and teacher-assigned grades as measures of student achievement. For the elementary (2-4) level students teachers provided a single overall grade and, for the secondary (6-12) level students teachers provided a grade for each subject. Their sample consisted of 82 teachers and 285 students at the elementary level and 424 students in the secondary level. The sample represented a large metropolitan public school district, a suburban school district, and a rural school district.

The Homework Process Inventory (HPI) (Cooper et al., 1998) was developed explicitly for this study to collect data about homework practices and procedures, beliefs and attitudes about homework from students, parents and teachers at different levels. Students, teachers and parents commented on how much homework the teacher typically assigned each night. Possible responses ranged from none (scored 1) to more that one hour (scored 5). At the elementary level
the questions referred to homework in general, since subject specific homework was not assigned to these students. For the secondary level, questions were subject-specific.

The HPI also asked students and parents how much of the assigned homework the student typically completed. Possible responses ranged from none (scored 1) to all (scored 5). The researchers constructed approximate measures of the amounts of time students spent on homework.

Analysis of the data revealed that 75% of the parents reported that their children completed all of the homework, whereas 65% of the students reported that they completed all of their homework. Also, elementary school teachers expressed more positive attitudes toward homework than did parents and students. Middle school and high school teachers expressed more positive attitudes towards homework than did parents and parents’ attitudes toward homework were more positive than students’ attitudes towards homework.

Student and parent reports of the portion of homework completed by students at both elementary and secondary levels were positively correlated with both measures of student achievement. At the elementary level, however, the correlation did not reach significance, but at the secondary level, correlations were significant. At the elementary level, the amount of time students spent on homework was not significantly correlated with standardized test scores, however, teacher-assigned grades were significantly negatively correlated with time spent on homework. At the secondary level, the amount of time students spent on homework was generally positively correlated with both achievement measures. For standardized test scores, the correlation was not significant but for teacher-assigned class grades, the correlation was significant.

**Homework and Feedback**

According to Bandura (1986), feedback about progress affects goals set for future performance. In skilled activities, performers see the results of their actions. Sufficiently detailed feedback specifies what aspects of the performance need to be corrected or improved. Feedback conveys signs of progress which can be either encouraging or disheartening depending on the level and characteristics of the performance.

Page (1958) conducted one of the first studies to determine the effects of feedback on student grades. He randomly selected 74 secondary school teachers from all teachers in three school districts. The classes, consisting of 2,129 students, equally represented all secondary levels from seventh to twelfth and most subjects. The classes were then assigned to one of three groups, the no comment group, the free comment group and the specific comment group.

Teachers administered objective tests and marked them in their usual way, so that each test showed a numerical score and a corresponding letter grade, A through F. Teachers of the no comment group did not provide a comment beyond the numerical score and the letter grade. Teachers in the free comment group wrote a personal note about each student’s effort. Teachers in the specific comment group wrote a comment based on the letter grade. For example, if the letter grade was an A, the teacher wrote “excellent, keep it up”, for letter grade B, “Good work, keep at it”, for letter grade C, “perhaps to do better”, for letter grade D, “let’s bring this up”, and for letter grade F, “let’s raise this grade”.

Page (1958) found that the free comment students achieved higher scores on the next objective test than the specific comment students and that the specific comment students did better than the no comment students. He found that all differences were significant except between the free comment and the specific comment groups. When he compared the class level during the next six years, no conclusive differences of comment effect appeared between the students. However, he observed that, “if anything, senior high was more responsive than junior high” (p. 180). He continues, “it appears logical to generalize the experimental results, at least to the early college years” (p. 180).

Schoen and Kreye (1974) conducted a study to determine the effects of written comments on homework for college students. Their sample consisted of 147 pre-service elementary teachers in an elementary mathematics course at Virginia Polytechnic Institute and at the State University. Students were placed into one of
three treatment groups, the no comment group, the general comment group and the specific comment group. In the no comment group, instructors marked homework problems correct or incorrect. In the general comment group, instructors not only marked a problem correct or incorrect, but also provided the correct answer with the correct solution. In the specific comment group, instructors not only marked problems correct or incorrect but also provided a comment about where and why the student’s solution was incorrect, along with the correct answer and solution.

Schoen and Kreye (1974) administered a posttest immediately at the end of the study and the same test six months after the study as a retention test. While they did not find any significant differences in achievement amongst the groups on the posttest, they found that students who received feedback specific to incorrect responses scored significantly higher on the retention test than did students who received no feedback or general explanations of the correct answer.

Bloom, Madaus and Hastings (1981) suggest that evaluation of homework is a factor to improve learning. Teachers provide value to students’ homework by assigning a grade to it. There is no research available that explores the effects of grading homework on student achievement. However, Murphy and Decker (1989) found that 88% of teachers graded homework. Most of these teachers not only checked to see that homework was finished, but also regularly provided letter or number grades on completed assignments. Sixty-nine percent of the teachers graded between 81% and 100% of the homework assignments and 14% of the teachers graded between 61% and 80%, while 17% of the teachers graded less than 60% of the homework assignments. “Although teachers were able to mark much of the homework they distributed, opportunity costs were associated with this commitment of time” (p. 267). Sixty-nine percent noted that the time required to grade homework sometimes (48%) or often (21%) influenced the amount or type of homework assigned.

Murphy and Decker (1989) also found that many teachers include homework as a percentage of the final grade in the classes (see table 2). The table shows the distribution between the percentage of the surveyed teachers who allotted some portion of the final grade to homework and the size of the portion (in %) of the homework in the final grade.

However, there is no research available to support the practice of either grading homework or including homework in the course grade.

Types of Homework

As Schoenfeld (1985) reports, homework assigned in remedial mathematics classes typically consists of 25 questions that can be worked in a total of 54 minutes. Presumably, these kinds of problems give the student the practice needed to reinforce skills.

In her study of a comparison of two high school Algebra textbooks, McBee (1984) examined the relationship between homework completion rates and student achievement. Her study examined the differences in achievement between Algebra students using a non-traditional textbook and Algebra students using a traditional textbook. The non-traditional textbook by Saxon (1981) presents the interrelationships of the number system as well as its social uses and included homework assignments, which required students to do review problems from previously studied topics in addition to problems incorporating new topics. The traditional textbook by Dolciani (1981) places emphasis on computational skills using algorithms. Homework assignments are designed to reinforce the application of only the most recently taught topic via drill and practice.

McBee (1984) found that the homework completion rate was identical for both groups, but that the homework “seemed to be more

<table>
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<th>Percent of the homework in the final grade (%)</th>
<th>Percent of teachers (%)</th>
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<td>5</td>
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Table 2. Percent of teachers including homework in final grade
beneficial” (p. 25) for the Saxon non-traditional students. The mean scores on the measure of student achievement, the California Achievement Test, of the students using the Saxon non-traditional text were significantly higher than the scores of the students using the Dolciani traditional text. Since both teachers assigned approximately equal amounts of homework, the researcher attributed the difference in homework benefit to the design of the textbook and instruction.

**BELIEFS ABOUT MATHEMATICS HOMEWORK**

The discussion about homework would not be complete if one does not refer to the issues related to beliefs about homework. Schoenfeld (1985) wrote that student actions follow student beliefs. If students do not believe that homework is a useful, meaningful activity, worthy of their time, they will not do it. In their survey of 210 students from seven rural Tennessee high schools, Reddick and Peach (1993) found that only 37% of the students believed that homework was useful. Often students do not do homework because they believe that the teacher does not think it is important. When the teacher assigns problems 1 – 71 odd, the students do not feel that the teacher made a deliberate attempt to plan meaningful and interesting homework. Such teachers send a signal that homework is not important, and the students believe that no thought was given to the selection of homework problems (Marquis, 1989). Hinchey (1996) also claims students believe that if homework is not collected, reviewed, commented on and/or graded then there is no need to complete the homework. Some students feel that if the teacher does not collect homework or if the teacher collects, reviews and grades it, but gives it back weeks later then the homework cannot be important.

Students are not making the connection between the assignment of the homework and the importance of the practice the homework provides to improve their skills. Many students feel that homework will not help them with class work (Hinchey, 1996). Some students feel that the homework is too easy so it does not have to be completed.

Cooper et al. (1998) found a relationship between student attitude towards homework and homework completion. For the secondary level (grades 6–12), they found that students’ attitudes toward homework were significantly positively correlated with student reports of the portion of homework completed and time spent on homework. They also found a non-significant negative relationship between student attitudes toward homework and standardized test scores, whereas a significant positive relationship was found between student attitudes and teacher-assigned class grades that involved homework portion. They summarized that positive student attitudes towards homework were associated with more completed homework and higher grades assigned by the teachers.

**SUMMARY AND THE AREAS FOR FUTURE RESEARCH**

This paper focused on research about the relationship between mathematics homework completion and student achievement in mathematics. The considerable body of research regarding the relationship between homework and mathematics achievement indicates that there is a positive relationship between homework completion and student achievement. In spite of the ongoing controversy about the importance, efficacy, quantity and type of homework, educators continue to employ, with various degrees of success, a variety of techniques to encourage students to complete their homework. But there is no consensus as to which type of homework assignments, in what quantity, for which age groups homework is most effective to develop homework as a habit that reinforces skills and knowledge. Future research that would investigate purposes, type, and/or amount of homework in community college remedial mathematics classes may shed light on the high failure rates.

Another area for future research could be related to the effects of feedback on homework on student achievement in community college remedial mathematics classes.

Beliefs play an important role in the activities in which students engage. Research that explores the beliefs and attitudes of community college remedial mathematics students about mathematics homework may provide insight into treatments to increase homework completion.
Homework is a contentious topic. Analysis of purpose, types, amounts of homework in community colleges.

Research on the relationship between homework and student achievement is not conclusive. Analysis of the relationship between homework completion and achievement of students in community college remedial mathematics classes.

Research indicates that there is a positive relationship between feedback on homework and student achievement. Analysis of the effects of feedback on homework on student achievement in community college remedial mathematics classes.

Research does not provide a coherent picture of the relationship between attitude, beliefs and achievement in mathematics. Analysis of community college student attitudes and beliefs about mathematics homework, homework completion and student achievement.

### Table 3. Summary/Areas for future research

Table 3 provides a summary of the research issues related to homework completion and achievement in mathematics and suggestions for future research.

The high level of failure rates in community college remedial mathematics classes is discouraging for the students and faculty alike. Community college faculty are frustrated when they see students who are able to do the work withdraw or fail in remedial mathematics classes because they do not do the homework. Further research is needed to explore variables associated with the relationship between homework completion and student achievement.

### References


### General Description of the Educational Doctorate in Mathematics and Science Education at UMass Lowell

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Students must pass a comprehensive and a qualifying exam prior to dissertation research.

**Who Should Apply?**

- K–12 teachers or Higher Education faculty who hold the equivalent of an undergraduate degree in mathematics, science, or engineering, together with a masters in any field.
- Teachers without an undergraduate degree in mathematics, science, or engineering, but who are PALMS specialists or National Board Certified in Science or Mathematics and hold a masters degree in any field.
Analysis of the Empirical Evidence of Factors in the Systematic Lesson Planning of Mathematics Teachers in Low-Performing Urban Middle Schools

Jeff Todd
Lowell Public Schools

ABSTRACT

This paper outlines a theoretical framework that guided the development of the Lesson Plan Evaluation Rubric (LPER) that was derived from the FSLP strategy (Panasuk, 1999). Through funding by the Massachusetts Department of Education, the FSLP strategy was the centerpiece of the Middle School Mathematics Initiative professional development program. Teachers from low-performing middle schools in eastern Massachusetts were trained in the FSLP strategy. At least five lesson plans gathered from 39 teachers throughout the 2001–2002 school year were analyzed using the LPER. I have used 261 lesson plans from the teachers to conduct a factor analysis of the 17 items from the LPER. There resulting four factors are worked-out problems, by-product pedagogical details, lesson coherence, and clear detailed specification of the objectives. These factors will be used in a further analysis to investigate the relationship of teachers’ written lesson plans to student mathematics achievement.

During my coursework in the Mathematics and Science Education Doctoral Program here at UMass Lowell, I worked with Dr. Panasuk on a project for the Massachusetts Department of Education. The Middle School Mathematics Initiative (MSMI) professional development program became the focus of my doctoral research and dissertation. It gave me the opportunity to deeply investigate the history of lesson planning and instruction. It gave me the opportunity to deeply investigate the history of lesson planning and instruction. It gave me the opportunity to deeply investigate the history of lesson planning and instruction. It gave me the opportunity to deeply investigate the history of lesson planning and instruction. It gave me the opportunity to deeply investigate the history of lesson planning and instruction. It gave me the opportunity to deeply investigate the history of lesson planning and instruction. It gave me the opportunity to deeply investigate the history of lesson planning and instruction.

LESSON PLANNING IN AMERICAN SCHOOLS

The principles of systematic lesson planning in education are usually credited to Tyler (1949) and have been further developed by the field of Instructional Development (ID) for the purpose of developing textbooks and educational media (Briggs, 1977; Merrill, 1971; Wong & Raulerson, 1974). While lesson planning and ID are separate fields, they share the same concern: the creation of material to promote student learning in the classroom environment. Driscoll, Klein, and Sherman (1994) argue that instructional developers and teachers think differently. Earle (1994) reflected,

It’s always surprising to me that two professional groups—teachers and instructional designers—who are so closely tied to a common goal: to facilitate and improve human learning—have remained separate and aloof for so long in both research literature and instructional theories and procedures. Admittedly, some efforts have been made to bridge the gap, but the reality is that very few teachers read ID literature, and very few instructional designers read teacher planning literature (p. 7).

The principles of Instructional Design include the use of behaviorally stated instructional objectives (emphasis on concrete skills that are observable and measurable) as a first step in planning, the alignment of assessment and instruction with objectives, and the decomposition of complex tasks into simpler tasks (Bloom, 1956; Gagne & Briggs, 1979; Gagne, Briggs & Wager, 1992; Mager, 1984; Tyler, 1949). Experienced teachers do not use these features of ID in a written form of lesson planning; rather, they employ some type of mental planning.
Teachers’ records of their lesson plans are “sketchy” (Reiser, 1994, p. 15), “quite brief” (Reiser & Mory, 1991, p. 77), or “cryptic shorthand” (Kagan & Tippins, 1992, p. 478). Branch (1994) reported that teachers rarely discuss objectives or lesson plans with other teachers or supervisors in the school.

Kennedy (1994) found in a study of Canadian teachers that most teachers “lacked even rudimentary knowledge to implement an instructional development approach. It seems likely that the respondents, all highly certified teachers with lengthy experience, were reluctant to admit their lack of knowledge and expertise in an area they felt they should know about” (p. 20). Only one-eighth of them were able to develop and classify behaviorally stated instructional objectives. Some of the most highly educated teachers believed that the use of behaviorally stated instructional objectives was “dehumanizing and restrictive” (p. 20).

Clark and Dunn (1991) discussed theoretical models for two perspectives of lesson planning, cognitive and phenomenological. Researchers who operate with the cognitive framework view planning as a psychological process of envisioning the future, considering goals and ways of achieving them, that is, teachers construct a framework to carry out their intentions. Researchers who operate with the phenomenological approach “have defined planning as the things teachers do when they say that they are planning” (p. 185).

Researchers from the phenomenological perspective such as Sardo-Brown (1988); Kagan and Tippins (1992); Bullough (1987); and Clark and Peterson (1986) question the need for training pre-service teachers in the use of objectives-first systematic lesson planning. In their study, Kagan and Tippins (1992) found detailed traditional lesson plans counterproductive for elementary and secondary teachers.

Applefield (1992), from the cognitive perspective stated, “we must do a better job of translating and modifying the essential elements of the ISD [Instructional Systems Design] process to make it efficient and effective for teachers at all levels, and compatible with teachers’ perceptions of the imperatives of teaching” (p. 7).

Panasuk’s Four Stages of Lesson Planning (FSLP) strategy (Panasuk, 1999; Panasuk & Cutler, 2001; Panasuk & Stone, 2002; Panasuk, Stone, & Todd, 2002, Panasuk, 2002) supports the cognitive framework and is based on the principles of instructional design: first stating behavioral instructional objectives, then planning homework that is aligned to the objectives, third planning the developmental activities consistent with the objectives and homework, and finally planning mental mathematics to review prior knowledge and to precipitate new learning. The strategy’s purpose is to shape and structure the complex process of mathematics lesson planning to ensure embedded assessment and consistency in student learning.

The Middle School Mathematics Initiative (MSMI) professional development program sponsored by the Massachusetts Department of Education implemented the FSLP strategy to affect the instructional core of teaching—lesson planning (Elmore, 2000). Hiebert and Stilger (2000) identify the lesson as the primary frame of reference for the analysis and reform of teaching. They call it the smallest unit that preserves the system of teaching.

The lesson is where the interactions occur among all the individual features of teaching. Students’ thinking, curriculum projects, pedagogical moves all must come together in a lesson....The classroom lesson seems just at the right level—large enough to capture the system, small enough to afford analysis and improvement.

A corollary of the fact that lessons capture the systems of teaching is that lessons afford teachers the opportunity of working toward improving teaching through careful planning, rather than relying solely on becoming more skillful on-the-fly decision makers. (p. 11)

As the substance of the MSMI professional development program, the FSLP strategy focused teachers on quality teaching (NSDC, 2001) by providing them with research-based instructional strategies to assist students in meeting rigorous academic standards, preparing teachers to use various types of formative and summative assessment, and deepening their
flexibility in using their content knowledge when preparing lessons. Teachers in eight low-performing school district received training in the Four Stages of Lesson Planning strategy and were encouraged to develop written lesson plans. Mathematics lesson planning was a focus of the MSMI program; therefore teachers' individual lesson plans become a primary unit of analysis. In order to evaluate teachers' written lesson planning, the researchers operationalized the FLSP as the Lesson Plan Evaluation Rubric. The following describes the theoretical framework from which the FSLP and LPER emerged.

DEFINING PEDAGOGICAL CONTENT KNOWLEDGE FOR MATHEMATICS TEACHING

Shulman (1987) defined pedagogical content knowledge (PCK) as “that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding” (p. 8). Figure 1, a Venn-diagram representation of this concept, shows PCK as the overlap of general pedagogical principles with specific content matter, in this case mathematics. Panasuk's (1999) Four Stages of Lesson Planning strategy is a means by which professional developers can investigate teachers' PCK and teachers can apply their PCK to the design, implementation, and reflection upon the lessons at the instructional core of their practice.

While the content of school mathematics teaching is well defined by the National Council of Teachers of Mathematics (NCTM 1989, 2000) and the Massachusetts Department of Education (2000), the pedagogy of teaching mathematics is more elusive. The works of Jean Piaget (1963/1952, 1970) provide a framework for the development of operational structures in middle school students. David Ausubel (1968) proposed meaningful verbal learning through the use of advanced organizers to link current learning to prior knowledge. Several researchers in the tradition of Hebert Simon (Larkin & Simon, 1987; Tabachneck-Schijk, Leonardo & Simon, 1997) define the notion of multiple representations. Together with theories from instructional design, the principles developed by Piaget, Ausubel, and Simon form the basis for pedagogical content knowledge for mathematics teaching that is pertinent to the FSLP strategy. Further, I will address each of these three aspects of the pedagogical content knowledge framework.

DEVELOPMENT OF OPERATIONAL STRUCTURES IN THE STUDENT

Piaget takes an epistemic position that knowledge is subjective. Each person’s intellect forms a view of the world and interprets external stimuli according to that view. Stimuli that are in accordance with the individuals’ preconceptions are assimilated into their body of knowledge. Stimuli that do not match create disequilibrium and the individuals must accommodate their intellectual structures to reenter a state of equilibrium. For children in particular, the accommodations result in the invariant development of operational stages: sensory-motor operations, concrete operations, and formal operations.

Piaget maintains that at about middle school age, students are at a unique stage of development when they develop operational structures permitting hypothesizing, reversibility, and combinatorial thinking that is independent of concrete experience. These structures allow for the formation of an “experimental spirit” in which students can identify factors

Figure 1. Venn Diagram of Mathematical Pedagogical Content Knowledge
in physical phenomena, create hypotheses, and develop tests for these hypotheses by manipulating the various factors. He stated, “Our schools often have no idea of the possible developments to be achieved from such aptitudes” (pp. 38–39).

Piaget (1970, p. 48) endorsed many of the recommendations for mathematics teaching of the International Conference of Public Education of 1956 sponsored by the International Bureau of Education and the United Nations Educational, Scientific, and Cultural Organization (UNESCO). These recommendations included: guiding students to form their own ideas rather than imposing ready-made adult thought; making sure students acquire operational processes before introducing formalism; putting mathematical experience before deductive reasoning; teaching students to pose problems, establish data, analyze them, and weigh the results; giving preference to heuristic investigation rather than doctrinal exposition of theorems; studying the mistakes of students to understand their thinking; training students in autocorrection; and giving priority to reflection and reasoning.

Based on the claim that the structure of mathematics is nearly identical to the operational structures of the child’s mind, the teacher’s is to help students connect their existing operational structures to a common symbolic language in order to express themselves in a mathematically literate way (Piaget, 1970, p. 47). This is in opposition to a transmissional model of mathematics teaching in which the student completes exercises modeled by a teacher as a means of establishing the capacity for mathematical thought.

Piaget (1970) also distinguishes between operational and figurative forms of knowledge. He equates operational forms of knowledge with intelligence, and for him, schooling should be focused on the development of the child’s operational structures. Figurative aspects of knowledge include perception and imitation of the external world. He claims that most teaching is directed at figurative knowledge instead of the development of operations.

**Linking New Learning to Prior Knowledge**

Building on the work of Piaget, Ausubel also considered the construction of knowledge as an active process on the part of the learner, giving particular attention to the role of verbal learning. Ausubel’s work (1968) was primarily focused on the development of a theory educational cognitive psychology. He established a definition of meaningful learning and developed a theory of advanced organizers that he claimed promotes meaningful learning.

Ausubel makes a distinction between meaningful and rote learning. Meaningful learning occurs when the learning task is related to the student’s prior knowledge, and the learner takes action to incorporate the learning task into the base of prior knowledge. Rote learning occurs when the student has a lack of prior knowledge to integrate the new learning, which results in the arbitrary associations of new ideas. Successful classroom learning occurs when there is a match between teaching of an instructional task and a preexisting cognitive structure of the learner.

Ausubel’s view of the cognitive structures refers to the “substantive and organizational properties of the learner’s existing knowledge” (p. 133). In order to facilitate meaningful learning, the teacher should assess the presence of stable and clear anchoring ideas in the student, use advanced organizers, and promote discrimination of current learning from other related cognitive structures.

Anchoring ideas refer to previously structured knowledge about a topic presented for a student. Ausubel (1968) stated, “the more background knowledge an individual has in a particular discipline, and the more stable this knowledge is, the more successful he is in learning related materials” (p. 134).

An advanced organizer (Ausubel, 1968) consists of a general overview of the material in advance of actually encountering its details and the organizing elements of the new material that are prior knowledge for the student. Organizers for completely unfamiliar material would focus on superordinate concepts that provide a framework for the new material, while organizers for relatively familiar material would focus on similar concepts, with the aim of increasing the student’s ability to discriminate.
“between new and existing ideas which are essentially different but confusably similar” (Ausubel, 1968, p. 149).

Ausubel (1968) argued that the advanced organizers are used to activate existing student cognitive structures and to affect the clarity, stability, discriminability, cohesiveness, and integrativeness of newly learned ideas through “explicitly pointing out in what ways previously learned, related ideas in cognitive structure are either basically similar to, or essentially different from, new ideas and information in the learning task” (p. 157).

Ausubel distinguished between advanced organizers and introductory overviews. Introductory overviews “are typically written at the same level of abstraction, generality, and inclusiveness as the learning material, and achieve their effect largely through repetition, condensation, selective emphasis on central concepts, and pre-familiarization of the learners with certain key words” (p. 331).

Ausubel viewed the use of advanced organizers as a benefit to low-achieving students. He viewed traditional means of teaching (without organizers) as primarily beneficial to students with high verbal ability, i.e., who were able to create mental structures independently. Commenting on the development of the late 1950s era Physical Sciences Study Committee (PSSC) Physics curriculum that used advanced organizers, he stated that “brighter students are evidently able to do for themselves part of what improved methods of teaching do for mediocre students” (p. 358). He noted that for unfamiliar material, advanced organizers differentially benefited low-achieving students more than high-achieving students. For relatively familiar material there was no differential benefit.

According to Ausubel, after establishing the newly learned concept in relationship to existing anchoring concepts, the teacher must establish the students’ ability to discriminate the difference between the newly learned material and similar material that are related to the anchoring concept. “Existing knowledge... tends to preempt the cognitive field and to superimpose itself on similar potential meanings.... The learner may be cognizant of the fact that new propositions differ somehow from established principals... but is unable to specify wherein the difference lies” (Ausubel, 1968, p. 142-143).

**Multiple Representations**

A third aspect of the PCK framework is the notion of multiple representations. The NCTM standards (2000) consider representations as both process and product, “to the act of capturing a mathematical concept or relationship in some form, and to the form itself” (Representations, paragraph 3). Students should be able to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; and use representations to model and interpret physical, social, and mathematical phenomena.

Representations may be considered as in-the-head or external (Roth & McGinn, 1998). In-the-head representations are cognitive structures that provide the means for thinking, reasoning, and problem solving. External representations can be thought of as re-presentations of the structure of in-the-head representations. Tabachneck-Schijff, Leonardo, and Simon (1997) provide a theory of multiple representations that can be applied to schooling.

Tabachneck-Schijff, Leonardo, and Simon (1997) discuss two aspects of representations: (1) a format for recording and presenting information, and (2) the processes for using and modifying the information. Neither the format nor the process is sufficient to define a representation (whether in-the-head or external). The researchers distinguish between two types of external representations, verbal and visual, that have different in-the-head processing structures. Multiple representations are differing verbal and visual means of communicating information inside the head of an individual to another person through external representations.

According to Ausubel, after establishing the newly learned concept in relationship to existing anchoring concepts, the teacher must establish the students’ ability to discriminate the difference between the newly learned material and similar material that are related to the anchoring concept. “Existing knowledge... tends to preempt the cognitive field and to superimpose itself on similar potential meanings.... The learner may be cognizant of the fact that new propositions differ somehow from established principals... but is unable to specify wherein the difference lies” (Ausubel, 1968, p. 142-143).
between novices and experts is the ability to make connections between verbal and visual representations.

This can be applied to the classroom in two ways. First, teachers must be content experts who have the flexibility to present and comprehend mathematics through different representational forms. Second, students’ progress from novice to expert can be assessed through their ability to represent mathematical ideas using various representations, in-the-head and with paper and pencil.

Scaife and Rogers (1995) note a shift in educational researchers’ conception of representations. They stated, “What we see emerging from this trend to broaden and situate the base from which to explain the cognitive behaviour is external representations (ERs) being given a central functional role in relation to internal cognitive mechanism” (p. 5). They discussed three characteristics of ERs that were central to the emerging theories: (1) the use of external representations allows for computational offloading for students (diagrams can allow students to perceive relationships efficiently while wordy descriptions would be cognitively demanding to reconstruct); (2) some forms of external representation are more useful than others, for instance, multiplication computations are easier to carry out using arabic numerals rather than roman numerals; and (3) graphicals can “constrain the kinds of inferences that can be made about the underlying represented world” (p. 5).

This notion of multiple representations corresponds to Piaget’s figurative knowledge. The perception and imitation of the various forms of mathematical representations (sentential, diagramatic, symbolic, etc.) do not alone provide the student with the opportunity to develop their cognitive operational structures. Teachers’ skillful application of the pedagogical content knowledge to lesson planning can provide students with opportunity to compare and contrast the differing forms, thus developing their capacity for operational thought.

**SUMMARY OF MATHEMATICS PEDAGOGICAL FRAMEWORK**

The development of students’ cognitive operational structures, the linking of current learning to prior knowledge, and the use of multiple representations provide the general pedagogical foundation for public school mathematics education. Among others, these three concepts form a cognitive perspective of classroom learning. Students are viewed as active learners. The conditions for meaningful learning are enhanced when a student’s base of prior knowledge is activated through advanced organizers. The use of multiple representations provides a framework for teachers to present new learning to students in more than one modality, and the opportunity for students to develop their cognitive operational structure by accommodating the various forms of representation. Students are expected to re-present newly learned ideas in more than one mode as they move from novices to experts thus providing teachers with evidence of student progress. This constructivist/cognitivist view of learning and teaching, together with the recently established national and local content standards for mathematics provide the professional knowledge base for teachers of mathematics. Combining this conception of pedagogical content knowledge with findings from the instructional design literature form the conceptual framework for the Four Stages of Lesson Planning strategy and the development of the Lesson Plan Evaluation Rubric.

**FOUR STAGES OF LESSON PLANNING STRATEGY**

Emerging from this framework of content and pedagogy is a view of mathematical pedagogical content knowledge that is combined with instructional design principles to form a strategy for mathematics lesson planning. Panasuk’s (Panasuk & Cutler, 2001; Panasuk & Stone, 2002; Panausk & Todd, 2002) Four Stages of Lesson Planning (FSLP) strategy is a structure for mathematics teachers by which they can apply professional knowledge in their classroom practice. The strategy is composed of sequential stages of planning of mathematics lessons: objectives, homework, developmental activities, and mental mathematics. Figure 2 shows the stages.

When lesson planning is viewed as evidence of teachers’ thought processes (Shavelson & Stern, 1981), engaging teachers by using the FSLP strategy demands an interaction of content with pedagogy. Written lesson plans and drafts of lesson plans provide a trail of evidence
that can be used to gain insight into teachers’ pedagogical content knowledge. When teachers work with an expert mentor during the lesson planning process, their pedagogical content knowledge can be uncovered and applied to their planning and teaching, thus furthering their development as teachers.

The sequence of the planning (but not delivery) stages begins with objectives, then homework, followed by developmental activities, and ends with the planning of mental mathematics. The lesson would typically be delivered in the sequence objectives, mental mathematics, development, and homework (Panasuk & Todd, 2002).

OBJECTIVES
are formulated in terms of students’ observable behavior

HOMEWORK
matches the objectives

DEVELOPMENTAL ACTIVITIES
reflect the objectives

MENTAL MATHEMATICS
activates prior knowledge, prepares students for the acquisition of new concepts

Instructional Environment
- Inquiry-Based Instruction
- Expository Teaching (Lecture)
- Labs and Projects

Instructional Approaches
- Problem Solving
- Multiple Representations
- Critical Thinking
- Communication
- Connections

Class Arrangements
- Individual
- Group Work
- Partner Work

The FSLP strategy emphasizes the importance of stating objectives for the lesson in terms of student observable behavior, as defined by Mager (1984). The development of observable objectives is usually associated with a behaviorist learning theory that is not supported by all educators (Anderson & Krathwohl, 2001). Nonetheless, this tenet of behavioral learning theory is seen as necessary by some adherents to cognitive learning theory (Haladyna, 1997), and it is consistent with the current idea of the standard-based curriculum NCTM (2000). The epistemic position of this paper is that knowledge is constructed by the learner (Piaget, 1970), and the development of
behaviorally stated instructional objectives is not in conflict with this epistemology.

Instructional objectives describe the intended outcome of learning and not the instructional procedure that is used (Mager, 1984). The objectives should describe the main intent(s) of the lesson, the behaviors or actions that the student be able to perform after participating in instructional activities. When formulating objectives that describe higher order cognitive processes, overt behaviors must be specified upon which the higher order process can be inferred. Mager recommends that the teachers ask of themselves three questions when preparing objectives: (1) what do I want students to be able to do; (2) what are the important conditions or constraints under which I want them to perform; and (3) how well must students perform for me to be satisfied?

Reasoning and problem solving are central to the development of higher level thinking. To evaluate students’ use of these covert processes teachers must use overt indicators. Bloom and his colleagues (1956) organized a list of verbs generally considered as overt observable behavior into a taxonomy of the cognitive domain. This taxonomy is useful in the development of objectives that overtly describe observable aspects of covert higher order cognitive processes. Using Bloom’s taxonomy, knowledge processes can be described at varying levels of complexity. Different mathematical tasks require different levels of thinking that can be describe in terms of various levels of objectives, from lowest to highest.

**Homework**

When instructional objectives are stated in terms of student observable behavior, the teacher designs appropriate homework to evaluate students’ ability to meet the objectives independently. Alignment of objectives, instruction, and assessment is integral to the instructional design. Misalignment of any of these three aspects will produce poor results on assessment—even when the quality of the development activities is excellent (Anderson & Krathwohl, 2001).

Homework and its sequential position in the stages of planning is critical feature of the FSLP strategy. There are many other instructional design strategies (e.g., Briggs, 1977; Gagné & Briggs, 1979; Merrill, 1971; Orlich, et al., 1990; Wong & Raulerson, 1974; and six others reviewed by Cruickshank, Bainer, & Metcalf, 1999), and most of them pay little or no attention to planning homework. If the lesson planning strategies address homework at all, it is usually considered after planning the developmental activities. Only one strategy proposed by Callahan (1971) addressed homework assignments as a distinct part of planning.

Gill and Schlossman (2000) observed that “homework remains a peripheral concern in teacher training institutions; there is only limited professional interest in translating the consensus for more homework into valuable educational experiences for students” (paragraph 55). According to the researchers, there is considerable “positive rhetoric” related to homework, but the actual homework expectation for students doesn’t match that rhetoric. Namboodiri, Corwin, and Dorsten (1993) found that when teachers focused students on homework, the students’ achievement improved.

Spadano (1996) noted that the educational literature focuses mostly on how to review homework in class. He argued that this reflects the common practice of teachers to assign homework, allow students to start the homework in class, and then review the homework during the next class period. Stigler, et al., (National Center for Education Statistics, 1999) also noted evidence of this pattern in American classrooms. As a result, students “learn that homework is not likely to be collected and evaluated, removing purpose and importance from the homework” (Spadano, 1996, p. 66). In contrast, Spadano showed that when students regularly and independently complete meaningful homework assignments outside the class, they learn to become autonomous learners and improve their self-control, self-discipline, and self-regulation.

During the first year of the MSMI program, the researchers evaluated 325 mathematics lessons plans in which both the instructional objectives and homework were specified (Panasuk, Todd, & Stone, 2001). The analysis showed a positive relationship between student achievement and the regularity with which teachers matched homework to the objectives.
**DEVELOPMENTAL ACTIVITIES**

It is a common practice to begin planning a lesson by searching for and selecting an activity. Such routine is not apparently based on instructional objectives, is not necessarily linked to the homework assignment, and in many classrooms does not contribute to student consistent and meaningful learning. The TIMSS Videotape Classroom Study (National Center for Education Statistics, 1999) presented a description of the developmental activities in American classrooms that is homogeneous across geographic, socioeconomic, and demographic categories. The activities in these classrooms follow a general script. The teacher demonstrates or explains examples the students are to reproduce, followed by a time when the students practice solving examples similar to what the teacher has shown.

The predominant practice in these classrooms from the 1990s was that mathematical concepts are stated to students rather than developed through explanation or derivation. On average, 78% of the concepts were stated to students. The development of activities was the same throughout 68% of the lessons, instead of increasing in complexity during the course of the lesson. The lessons tend to address several topics (55%) instead of being focused on a single concept. None of the observed lessons encouraged inductive reasoning.

Students in these classrooms were not prompted or were discouraged from using alternative solution routes. Teachers determined the solution route for 83% of the tasks. When alternate solution methods were presented, they were generated by teachers in 70% of the classrooms. Student seatwork was described as practicing routine procedures for 96% of the observed tasks that they were assigned. These findings are at odds with the NCTM’s goals of educational reform (National Center for Education Statistics, 1999), and are described better by Ausubel’s (1968) theory of rote learning rather than his theory of meaningful verbal learning.

The FSPL strategy suggests planning the developmental activities after the objectives and the homework are specified. Such planning provides a basis for strong bonds and consistency between the objectives, the means of meeting the objectives, and the homework as a form of assessment. The FSPL strategy, emphasizes that the developmental activities must provide the context for meaningful student learning. The results of this phase of lesson planning should be a set of worked-out problems or student activities that include teaching strategies, arrangement of the class, and instructional approaches.

Panasuk and Todd (2002) argued that the developmental activities must help the student to observe different patterns, to see mathematics as a unified system of notions, definitions, concepts and operations that describe and explain the patterns and quantitative relationships that exist in the real world. Students must have an opportunity to examine collected information and search for common properties and patterns, which suggest relationships or structure. The students have to learn how to translate the general ideas into mathematical language by means of carefully defined terms and concise symbolic representations, which add precision to communication.

If teaching a concept begins with simply pointing out the definitions or rules and is followed by teacher telling procedures, the natural process of learning the concept is reversed potentially limiting students' mathematical power. Such an instructional approach provokes students to view mathematics as an unrelated set of rules and procedures. Many students experience difficulty when applying their knowledge and skills because they are, at large, fragmented, isolated, and mechanical. To make the process of learning mathematics meaningful, students must see the development and the relationship among concepts and make sense of what they study. Symbols and formal representations of mathematical concepts must be presented gradually from the concrete to the abstract.

Developmental activities represent a synthesis of mathematics content and teaching strategies. These strategies include problem solving, inquiry-based instruction, expository teaching (lecture), labs and projects, instructional approaches (i.e. multiple representations, critical thinking, and communication), and class arrangements, such as individual seatwork, group work, or partner work.
Dubinsky and Lewin (1986) asserted that in the efforts of facilitating learning, what is usually lacking is an attempt to orient or design instruction around the actual process of learning. They argued that encouraging students to learn new material by imitating the teacher's behavior or listening to a lecture is not effective. Rather, it is more productive to develop an analysis of the mental processes by which new concepts are acquired, and base the lesson on this. They continued that while it is the students’ responsibility to construct knowledge themselves and not to duplicate the knowledge structures of others, the students must be exposed to the pre-disposing structures and influences created by an expert who explains and illustrates all the prerequisite structures, both necessary and sufficient, for the cognitive act to occur.

As teachers perform task analysis during lesson planning, they have an opportunity to predict the kinds of naïve or misconstrued conceptions that student may have. Through planning examples to address the misconceptions, teachers can try to establish conditions for students to rethink their naïve conceptions about mathematics.

Because of the verbal nature of learning, an important consideration in developmental activities is the grouping of the students. Verbal learning can be accomplished through direct instruction from the teacher, classroom discussion moderated by the teacher but focusing on student discourse, or small groups and pairings, allowing students to have more of a chance to verbalize their thinking processes to each other. This sociocognitive view of classroom discourse (Resnick, Levine, & Teasley, 1991) offers opportunities to assess student thinking and learning informally, as it occurs. Such classroom discourse is consistent with the NCTM (2000) goal of communicating about mathematics.

By choosing examples that relate to subordinate mathematical concepts, using multiple representations, and carefully considering student grouping, the teacher plans the developmental phase of the lesson allowing students to grapple with new mathematics within their zone of proximal development (Vygotsky, 1986). While within this zone, students ideally have the opportunity to progress from their actual level of development to their potential developmental level.

**Mental Mathematics**

As a final stage, planning of mental mathematics integrates and is based on all three previous stages. Constructing mental mathematics activities, teachers design brief and fast-paced problems that are basic elements of prior knowledge as well as prerequisites of the new learning (Panasuk, 2002; Panasuk & Cutler, 2002) The mental mathematics concept is based on Gagné’s (1965) hierarchy of principles, also known as task analysis, and Ausubel’s (1968) theory of advanced organizers.

By first constructing instructional objectives and then designing homework to assess success in achieving those objectives, teachers then solve the homework exercises or problems and develop activities that prepare students to meet the objectives and enable them to complete the homework independently. To be able to plan mental mathematics (as well to present a concept in its development rather then in its completed and refined form), the teacher ought perform concept/task analysis by scaffolding the concepts, skills and knowledge to be learned. The idea of task analysis is rooted in Gagné’s (1965) structure of organized knowledge. He stated that knowledge about a principle can be decomposed into subordinate subconcepts:

The psychological organization of knowledge may be represented as a *hierarchy of principles*. As previously shown, two or more concepts may be prerequisite to (and in this sense subordinate to) the learning of a single principle. Similarly, two or more principles may be prerequisite to the learning of a superordinate principle. Once the latter is learned, it may combine with another principle to support the learning of still another higher-level principle, and so on. The entire set of principles, organized in this way, forms a hierarchy that may be called the *structure of organized knowledge* about a topic. (p. 151)

While this theory has been somewhat criticized when it is used to construct rigorous
structures of organized topics for whole fields such as mathematics (Carifio, 1979), there is general agreement that this decomposition of prerequisites for a particular principle to be learned is helpful in developing specific lessons (Ausubel, 1968; Carifio, 1979; Gagne, 2001).

Even when mathematics teachers are content experts, it cannot be assumed that they have been trained to decompose mathematical ideas. Tabachneck-Schijf, Leonardo, and Simon (1997) noted that an expert college professor could make a complex drawing of a concept, but could not decompose it into smaller ideas. Roth and McGinn (1998) stated,

To many experts, the adequation [statement of equivalency] of two different inscriptions is self-evident, intuitive, and straightforward. But these experts forget that the self-evident, intuitive, and straightforward way in which a series of data pairs are re-presented as sequences, as a table, or as a graph, took years of training within specific social, historical, and cultural contexts. (p. 41)

Through engaging in the process of task analysis during the lesson planning process, teachers formally consider the prerequisite knowledge needed to meet the lesson’s objectives. Having identified the prior knowledge anchoring ideas necessary for the learning, the teacher can create mental mathematics activities to be used prior to the development of the new topic.

Mental Mathematics, as it is presented in the FSLP, is similar in some way to and is based on the Ausubel’s (1968) concept of advanced organizers. As Ausubel suggested, “The principle function of the organizer is to bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand” (p. 148). The organizers should be formulated in language and concepts familiar to the students (p. 331).

The concept of the advance organizer and task analysis is a cornerstone of planning mental mathematics. By doing task analysis; of the already planned homework and developmental activities, teachers can identify the prerequisite knowledge needed by students for success in learning the new material. Turning these prerequisites into a series of mental mathematics exercises for use at the beginning of the class prepares students by activating their prior knowledge and gives them a sense of how the day’s lesson is similar to and different from their existing knowledge base.

**Other Aspects of the FSLP Strategy**

Assessment and phases of lessons are two other elements of lesson planning that are embedded and encouraged throughout the FSLP strategy.

Formative and summative forms of student assessment and evaluation are equally important and must be practiced consistently. Branch and Gustafson (1998) define formative evaluation as “identifying needed revisions to the instruction” and summative evaluation as “being directed to assessing the degree to which the objectives have been achieved” (p. 5). Homework is a form of summative assessment when considered in the context of a daily lesson. It is the indicator of whether students are able to independently meet the instructional objectives.

Panasuk and Todd (2002) asserted that classroom practice must be designed to explicitly or implicitly provide information from which teacher and students will be able to make informed decisions with the goal of changing behavior and improving performance. Assessment has a formative role when it is integrative in design and implementation. Planning lessons, teachers must think about the evaluative tools that would inform them about student learning during instruction.

Airasian (1994) and Stiggins (2001) suggest that student questioning is an integral aspect and the most common form of teacher/student interaction and formative evaluation. Planning questions in advance of instruction, asking clear and not-overly-broad questions, and probing for reasoning and not just facts and information are important aspects of questioning that are central to teacher/student interactions and assessment.

In addition to its function of surfacing prior knowledge, the use of mental mathematics is an example of formative assessment, as it informs the teacher whether or not the students are
ready for the planned lesson. While planning the developmental activities, the teacher outlines key questions to understand students’ progress toward the instructional objectives. When students are engaged in cooperative activities, the teacher assesses students’ progress using previously planned indicators that inform her of the success of the activity.

Phases of the lesson are discrete components of the planned instruction. The FSLP strategy implicitly defines a mental mathematics phase in addition to developmental phases of the lesson. Within the developmental activities there are teacher expository phases and student activities (Henderson, 1969). While traditional models of education tend to have a phase of teacher exposition followed by student practice (National Center for Education Statistics, 1999), it is common in classrooms using guided inquiry that student activities are usually followed by a teacher-directed discussion (Henderson, 1969). A final phase of the lesson is homework orientation and guidance. The teacher summarizes the lesson and refers to the homework assignment, noting its relationship to the problems solved in class and indicating possible difficulty.

THE LESSON PLAN EVALUATION RUBRIC

During the Middle School Mathematics Initiative professional development program, lesson planning and delivery evaluation models (Panasuk, 1987; Panasuk, Simonova, & Chistyakova; Panasuk & Sullivan, 1998; Panasuk & Sullivan, 1998) were operationalized as the Lesson Planning Evaluation Rubric (LPER, Appendix A) in order to provide consistency with the FSLP.

Based on the experience of the first year of the program, the UML research team and the Specialists vetted the rubric during the fall training of the second year. Throughout the second year, as the team met, they developed a scoring manual for the rubric (Appendix B). The seventeen-item rubric has a range of scores from zero to 37 points.

ANALYSIS OF THE LPER DATA

The Specialists used the LPER to score the lesson plans of the MSMI professional development program’s teachers. Researchers at UML also scored each lesson plan. Both the Specialists and the UML researchers reviewed all discrepancies in applying the rubric to the lesson plans resulting in 100% agreement on all items.

The researchers gathered and examined 261 plans generated by 39 teachers from low-performing urban middle schools in eastern and central Massachusetts. Each teacher contributed at least five and no more than eight lesson plans. The mean number of lesson plans per teacher was 6.7.

I completed a principal components analysis of the data using the software, Statistical Package for the Social Sciences (SPSS, 2000), with Varimax rotation and Kaiser normalization. The LPER items clustered into four factors and accounted for 48% of the variance (see Table 1). The highest loading for each LPER item is highlighted in bold with secondary loadings (over .300) in italics.

Kachigan (1986) states that a central purpose of factor analysis is to distill the essence of items that are highly loaded on a particular factor by giving a name to the factor. This higher order abstraction “provides a completely novel way of viewing the subject matter, and may contribute to the development of other hypotheses that could be tested in subsequent research studies” (p. 394). Naming the factors I took for account

<table>
<thead>
<tr>
<th>Item</th>
<th>Percent of Variance</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.1 Objectives</td>
<td>25.5%</td>
<td>0.080</td>
</tr>
<tr>
<td>2.1 Homework linked to objectives</td>
<td>2.1 Homework worked out</td>
<td>0.091</td>
</tr>
<tr>
<td>2.2 Homework worked out</td>
<td>0.607</td>
<td>0.221</td>
</tr>
<tr>
<td>3.1A Mental math worked out</td>
<td>0.653</td>
<td>0.140</td>
</tr>
<tr>
<td>3.1B Teacher problems worked out</td>
<td>0.772</td>
<td>0.069</td>
</tr>
<tr>
<td>3.1C Student problems worked out</td>
<td>0.814</td>
<td>0.003</td>
</tr>
<tr>
<td>3.2 Student grouping</td>
<td>0.000</td>
<td>0.707</td>
</tr>
<tr>
<td>4.1 Mental math criteria</td>
<td>0.155</td>
<td>0.102</td>
</tr>
<tr>
<td>5.1 Phases of the lesson</td>
<td>0.166</td>
<td>0.670</td>
</tr>
<tr>
<td>5.2 Logical flow of the phases</td>
<td>0.362</td>
<td>0.288</td>
</tr>
<tr>
<td>5.3 Embedded Assessment</td>
<td>0.170</td>
<td>0.548</td>
</tr>
<tr>
<td>5.4 Time guides</td>
<td>0.141</td>
<td>0.589</td>
</tr>
<tr>
<td>6.1 Aligned to MMCF</td>
<td>0.160</td>
<td>0.541</td>
</tr>
<tr>
<td>6.2 Multiple representations</td>
<td>0.024</td>
<td>0.155</td>
</tr>
<tr>
<td>6.3 Special need adaptations</td>
<td>0.226</td>
<td>0.352</td>
</tr>
<tr>
<td>6.4 Student misconceptions</td>
<td>0.272</td>
<td>0.143</td>
</tr>
<tr>
<td>6.5 No mathematics errors</td>
<td>-0.052</td>
<td>0.300</td>
</tr>
</tbody>
</table>
Kachigan’ warning that “a careless naming of the factors might be completely misleading, jeopardizing the conclusions of the study” (p. 394). Kerlinger and Lee (2000) concur stating

In considering the scientific value of factor analysis, the reader must be cautioned against attributing “reality” and uniqueness to factors. The danger of reification is great. It is easy to name a factor and then to believe there is a reality behind the name. But giving a factor a name does not give it reality. Factor names are merely attempts to epitomize the essence of factors. They are always tentative, subject to later confirmation or disconfirmation. (p. 856)

Taking into account the above opportunity and warnings about factor analysis, I will discuss what the essential underlying constructs the LPER may measure.

**Factor 1: Worked-Out Problems.** Of the four factors, the naming of this factor is the most clear. The four items that load strongly on this factor (items 2.2, 3.1a, 3.1b, and 3.1c) all relate to having worked out the problems in the lesson plan, the homework problems, the mental mathematics problems, the problems that teacher would use during instruction, and the problems that the students would complete during the class. There was also a moderate loading of item 5.2, logical flow of the lesson through the phases which is consistent with having worked out the problems from the various phases.

This factor accounted for the largest part of the variance, 25.5%, while the other three factors accounted for between 6 and 9%.

**Factor 2: By-Products of FSLP.** This factor consisted of six items that were strongly related, student grouping (item 3.2), the presence of distinct and specific phases of the lesson aligned to the FSLP (item 5.1), embedded assessment in each phase (item 5.3), timing guides for each phase (item 5.4), alignment to the state mathematics frameworks (item 6.1), and modifications for special needs students (item 6.3). Identifying the essence of these items is more elusive because at first glance, they seem to be unrelated.

Nonetheless, there is an important underlying organizing principle to these items: they are logical by-products of the FSLP strategy. This lesson planning strategy results in a lesson that is structured in phases: an opening activity, developmental activities that include at least a teacher-directed phase and student activities (in pairs, groups, or individually), and a phase to explicitly link the homework to the lesson’s activities. The lesson phases have time guides for better-structured and conducted lesson. Two items are related to the specification of the objectives: state standards guide the formation of instructional objectives (item 6.1), and embedded assessment (item 5.3) allows the teacher to make adjustments to lesson if students are not making sufficient progress toward those objectives. Student grouping and attention to modifications for special needs students (items 3.2) are logical outcomes of careful attention to planning the development stage of the lesson.

In my view, these items are related as logical outcomes of the FSLP strategy, I chose the name *by-products of FSLP* as a descriptor. This factor accounted for 8.7% of the variance explained by the factor analysis.

**Factor 3: Lesson Coherence.** Three items are strongly loaded onto this factor, homework linked to instructional objectives (item 2.1), specification of the mental mathematics in light of the objectives (item 4.1), and the logical flow of the lesson through the phases (item 5.2). Two other items were moderately loaded onto the factor, distinct phases of the lesson (item 5.1) and embedded assessment (item 5.3).

I infer that these items are related to the coherence of the lesson. It is a core proposition of the FSLP strategy that well-structured lessons flow from well-specified, behaviorally stated instructional objectives. The items associated with this factor included homework and mental mathematics linked to objectives. The logical flow of the lessons through the phases received higher scores if the lesson was related to the objectives. Because a fundamental principal of the FSLP strategy is that all parts of the lesson are related to the objectives, it is not surprising that these items cohere to each other. The moderately related items were concerned with the structure of the phases—their clarity and use of formative assessment in each phase. These are also related to the coherence of the lesson and
its adherence to the objectives and assessment of student progress toward the objectives.

Because the lessons were developed with the FSLP strategy and its objectives-first focus, teachers whose lesson plans followed this strategy exhibited a higher degree of lesson coherence that I chose as the name for this factor. This factor accounted for 7.2% of the variance explained by the factor analysis.

**Factor Four: Detailed Specification of Objectives.** Four items were strongly loaded on the final factor, the specification of behaviorally stated instructional objectives (item 1.1), the use of multiple representations (item 6.2), specification of student misconceptions (item 6.4), and mathematical errors (item 6.5). Two items were moderately related to this factor, the specification of mental mathematics in light of the objectives (item 4.2) and the alignment to the state mathematics framework (item 6.1).

Item 6.5 should be removed from consideration as part of the factor analysis. Cronbach’s alpha, a method of correlation to determine the internal validity of measurement items is improved item 6.5 is removed. This item is uncorrelated to the other items in the LPER.

Factor four is again tied to the objectives phase of the FSLP strategy, but differs from factor 3 in the following way: factor three is related to lesson coherence while factor four is related to the specification of the objectives. The highest score for item 1.1 on the LPER was that the objectives specified not just the mathematical concepts that student would learn, but also the types of skills that they would exhibit. Thus, objectives might state that students would be able to recognize, draw a picture, explain, or interpret a graph, for example.

Having specified the details of the mathematics content that students would learn, teachers were more able to develop well specified mental mathematics activities (item 4.1) and include a wider array of multiple representations. Perhaps it was the other way around—because teachers became aware of the subskills present through deriving mental mathematics activities and considering multiple representation of mathematics concepts, they may have produced more refined objectives. The purpose of the factor analysis is not to determine cause and effect, but to surmise the relationship between the items within the factors.

**CONCLUSION**

The MSMI professional development program provided a unique opportunity to collect and analyze the lesson plans of middle school mathematics teachers in low-performing middle schools in Massachusetts. Having developed the Lesson Plan Evaluation Rubric to be consistent with the Four Stages of Lesson Planning strategy and its conceptual framework, the researchers were able to develop four underlying factors in the LPER data: worked out problems, by-products of FSLP, lesson coherence, and detailed specification of the objectives.

As a part of my ongoing dissertation data analysis, I will use these four factors as part of a multi-level model of the student achievement results of the MSMI program. As the initial results of the program’s analysis show improved student achievement against a comparison group, I expect to be able to investigate whether these four factors of written lesson planning are related to student achievement. Establishing links between aspects of systematic lesson planning and student achievement would be a strong contribution to the field of mathematics education.

**References**


SPSS. (2002). *SPSS 10.0 for the Macintosh, Version 10.0.7a*. Chicago: SPSS.


# Appendix A

## LESSON PLAN EVALUATION RUBRIC

**TEACHER NUMBER:**  
**DATE OF OBSERVATION:**

<table>
<thead>
<tr>
<th>1.1</th>
<th>OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>All objectives are stated in terms of student observable behavior and specified skills and knowledge</td>
</tr>
<tr>
<td>3</td>
<td>All objectives are stated in terms of students observable behavior, but do not specify skills and knowledge</td>
</tr>
<tr>
<td>2</td>
<td>Some objectives are stated in terms of student observable behavior</td>
</tr>
<tr>
<td>1</td>
<td>Objectives are stated, but none are in terms of student observable behavior</td>
</tr>
<tr>
<td>0</td>
<td>No objectives are stated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.1</th>
<th>HOMEWORK: LINKED TO OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Homework problems are listed, match the objectives, and contain some problems that reinforce students' prior knowledge</td>
</tr>
<tr>
<td>2</td>
<td>Homework problems are listed and match the objectives</td>
</tr>
<tr>
<td>1</td>
<td>Homework problems are listed, but do not relate to the objectives</td>
</tr>
<tr>
<td>0</td>
<td>No homework is addressed in the lesson plan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.2</th>
<th>WORKED-OUT PROBLEMS—HOMEWORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>All homework problems have been worked out</td>
</tr>
<tr>
<td>1</td>
<td>Some key homework problems have been worked out</td>
</tr>
<tr>
<td>0</td>
<td>None of the homework problems have been worked out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.1A</th>
<th>WORKED-OUT PROBLEMS—MENTAL MATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Every (or nearly every) mental math problem have been worked out</td>
</tr>
<tr>
<td>1</td>
<td>Some (particularly some key) mental math problems have been worked out</td>
</tr>
<tr>
<td>0</td>
<td>None (or very few) of the mental math problems have been worked out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.1B</th>
<th>WORKED-OUT PROBLEMS—DEVELOPMENT (TEACHER'S PRESENTATION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>All problems have been worked out</td>
</tr>
<tr>
<td>2</td>
<td>Key problems critical to the development have been worked out</td>
</tr>
<tr>
<td>1</td>
<td>Some problems have been worked out, but not at least one problem critical to the development</td>
</tr>
<tr>
<td>0</td>
<td>None (or very few) of the problems have been worked out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.1C</th>
<th>WORKED-OUT PROBLEMS—CLASSROOM EXERCISES (STUDENTS' WORK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>At least key problems for the students' work have been worked out</td>
</tr>
<tr>
<td>0</td>
<td>None (or very few) of the problems for the students' work have been worked out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.2</th>
<th>STUDENT GROUPING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Student grouping for activities (seatwork, pairs, group work, etc.) is indicated</td>
</tr>
<tr>
<td>0</td>
<td>Student grouping for activities is not indicated</td>
</tr>
</tbody>
</table>
4.1 **MENTAL MATH (PLEASE CIRCLE THE ELEMENTS YOU FIND IN THE LESSON)**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The opening activity relates to the objectives, focuses on subskills needed for the lesson, and surfaces student prior knowledge</td>
</tr>
<tr>
<td>2</td>
<td>The opening activity has two of the above characteristics</td>
</tr>
<tr>
<td>1</td>
<td>The opening activity has one of the above characteristics</td>
</tr>
<tr>
<td>0</td>
<td>The opening activity has none of the above characteristics or there is no opening activity</td>
</tr>
</tbody>
</table>

5.1 **PHASES OF THE LESSON (PLEASE CIRCLE THE ELEMENTS YOU FIND IN THE LESSON)**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The lesson contains at least four phases: Opening Activity, Teacher Exposition of Material, Student Activities (group work, seat work, etc.), Closing Summary with Preview of Homework</td>
</tr>
<tr>
<td>2</td>
<td>Three of the four phases are present in the lesson plan</td>
</tr>
<tr>
<td>1</td>
<td>Two of the four phases are present in the lesson plan</td>
</tr>
<tr>
<td>0</td>
<td>One or none of the four phases are present in the lesson plan</td>
</tr>
</tbody>
</table>

5.2 **LOGICAL FLOW OF THE LESSON THROUGH THE PHASES**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The exposition and activities clearly provide logical links between students' prior knowledge and the skills needed to complete the homework</td>
</tr>
<tr>
<td>2</td>
<td>The logical flow of the lesson is unclear, but related to the objectives</td>
</tr>
<tr>
<td>1</td>
<td>The logical flow of the lesson is not related to the objectives</td>
</tr>
<tr>
<td>0</td>
<td>There are no phases indicated in the lesson plan</td>
</tr>
</tbody>
</table>

5.3 **EMBEDDED ASSESSMENT**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The embedded assessment is clearly identified in each phase of the lesson</td>
</tr>
<tr>
<td>2</td>
<td>The embedded assessment is clearly identified for some phases of the lesson</td>
</tr>
<tr>
<td>1</td>
<td>The embedded assessment is not clear but can be inferred for at least one phase of the lesson</td>
</tr>
<tr>
<td>0</td>
<td>There is no evidence of embedded assessment</td>
</tr>
</tbody>
</table>

5.4 **TIME GUIDES**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There are at least four phases with time guides that are appropriate and total time agrees with the period length</td>
</tr>
<tr>
<td>0</td>
<td>There are few or no time guides</td>
</tr>
</tbody>
</table>

**OTHER ELEMENTS OF LESSON PLANNING**

6.1 **ALIGNED WITH STANDARDS**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>The objectives are adequately referenced to the state MCS using strand and standard number</td>
</tr>
<tr>
<td>1</td>
<td>The objectives incorrectly reference the state MCS using strand and standard number</td>
</tr>
<tr>
<td>0</td>
<td>The objectives do not reference the state MCS using strand and standard number</td>
</tr>
</tbody>
</table>

6.2 **MULTIPLE REPRESENTATIONS (PLEASE CIRCLE THE ELEMENTS YOU FIND IN THE LESSON)**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Classroom examples incorporate all three forms (pictorial/concrete, verbal, symbolic) of representation</td>
</tr>
<tr>
<td>1</td>
<td>Classroom examples incorporate two of the three forms of representations</td>
</tr>
<tr>
<td>0</td>
<td>Classroom examples incorporate only one form of representation</td>
</tr>
</tbody>
</table>
### 6.3 ADAPTATIONS FOR SPECIAL NEEDS

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The lesson has been adapted/extended to meet individual students’ needs</td>
</tr>
<tr>
<td>0</td>
<td>There is no indication that the lesson has been adapted/extended to meet individual students’ needs</td>
</tr>
</tbody>
</table>

### 6.4 ADDRESSING STUDENT MISCONCEPTIONS

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>There is an indication of at least one possible student misconception and a plan to address the misconception(s)</td>
</tr>
<tr>
<td>1</td>
<td>There is an indication of at least one possible student misconception(s)</td>
</tr>
<tr>
<td>0</td>
<td>There is no indication of possible student misconceptions</td>
</tr>
</tbody>
</table>

### 6.5 MATHEMATICS CONTENT

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The lesson plan contains no mathematical errors, or only minor mathematical errors</td>
</tr>
<tr>
<td>0</td>
<td>The lesson plan contains several mathematical errors, or serious mathematical errors</td>
</tr>
</tbody>
</table>

SCORER:  
DATE OF SCORING:  
TOTAL SCORE:
Appendix B

LPER SCORING STANDARDS
JANUARY 2002

1.1 OBJECTIVES

4 points, must specify skills with the details in words, not symbols, 50% or more of the objectives must be “specific” to score 4 points—a good question to ask is: if another teacher were given these objectives, how likely is it that the lesson plans would be similar

3 points, all objectives must be stated behaviorally

2 points, at least one objective is stated behaviorally

2.1 HOMEWORK: LINKED TO OBJECTIVES

3 points, must have at least two homework “problems” that check for prior knowledge, where prior knowledge is defined by the teachers in the lesson plan

2 points or 1 point, problems are listed means that either the actually assignment is attached or if the problems are from a book, that the page number and problem numbers are specifically listed—the specialists should include the photocopy of the book page. The teacher does not need to copy the actual problems into the lesson plan. The difference between 2 points or 1 point is whether the homework matches the objectives. The homework has no match at least one of the objectives.

2.2 HOMEWORK: WORKED-OUT PROBLEMS

2 points, all homework problems are done out

1 point, more than one, but not all problems are done out

0 points, one or no homework problems have been done out

3.1 DEVELOPMENT: WORKED-OUT PROBLEMS (SPLIT INTO 3.1A, 3.1B, AND 3.1C FOR CLARITY)

3 points, all classwork problems are done out including all seatwork/groupwork problems

2 points, some classwork problems are done out, and at least one significant problems is done out from each phase of the lesson, along with one problem of each type for any seatwork/groupwork

1 point, some classwork problems are done out, but there is at least one (non-homework) phase where no problems are worked out.

3.2 DEVELOPMENT: STUDENT GROUPING

1 point, student grouping must be specifically mentioned by the teacher. For instance: students will work alone, students will work with a partner or in pairs, students will work in groups of four, student will work in their regularly assigned groups.
4.1 MENTAL MATH
relates to objectives—the mental math problems have some relation to the objects—as opposed to problems that have nothing to do with the objectives—don’t need to nitpick about an exact match to the objectives

focuses on subskills—the mental math problems are based on having broken down the objectives to subskills that are needed for the lesson. Mental math problems that exactly reflect any objective in its entirety should not be given the point—it must be broken down

surfaces student prior knowledge—the mental mathematics problems should surface the student prior knowledge that the teacher has previously listed in the lesson plan

5.1 PHASES OF THE LESSON:
MUST BE AT LEAST FOUR
Opening Activity—should be mental mathematics, but other activities could be used
Teacher Exposition—there should be some part of the lesson that the teacher provides information or direction to the student
Student Activities—there should be some part of the lesson when the students work alone or in groups on some kind of activity/seatwork
Closing Summary/Homework Preview—The homework should be previewed—this could be indicated by allocating at least four minutes at the end of class to go through a couple of problems. If the homework is previewed in earlier phases of the lesson, a closing summary must be provided

5.2 PHASES OF THE LESSON: LOGICAL FLOW
The flow of the lesson does not need to be perfect. There are two main ideas to consider: (a) does the lesson build a bridge from the listed student prior knowledge to the assigned homework, and (b) does the lesson flow from one idea to the next

3 points, meets the above criteria
2 points, does not meet the above criteria, but is related to the objectives
1 point, lesson does not relate to the objectives

5.3 PHASES OF THE LESSON: EMBEDDED ASSESSMENT
The main point is that teachers have a plan to receive feedback from the students as to whether they are grasping the lesson’s content. If the teachers asks for student responses, or if the teacher poses questions to the students, then that is considered embedded assessment

3 points, assessment occurs in the opening activity, in the closing/homework section and at least in two other distinct places in the development
2 points, assessment occurs in more than one phase, but does not meet the criteria established for 3 points
1 point, assessment occurs in only one phase
5.4 PHASES OF THE LESSON: Time Guides

1 point, there are at least four distinct phases for which there are time guides and the total time is the same (or close) to the intended length of the class

6.1 ALIGNED WITH STANDARDS

Look up the cited standard(s) and make sure that it/they best represent the content of the lesson

6.2 MULTIPLE REPRESENTATIONS

Verbal—it is likely that all lessons contain verbal forms of representation

Pictorial/concrete—some kind of non-numerical drawing or manipulative is used—factor trees are acceptable

Symbolic—use or manipulation of numerical or operational symbols

6.3 ADAPTATION FOR SPECIAL NEEDS:

1 point, the lesson must be adapted for some student. The use of multiple representations is not sufficient. If there is an aide, how (very specific) will the aide be instructed to modify the lesson? How will the homework be modified? What will be done for a student who completes work early? These are specific modifications for specific students.

6.4 ADDRESSING STUDENT MISCONCEPTIONS:

2 points, the teacher has identified a common misconception for the lesson and has come up with a plan, a set of problems, a set of questions, some sort of evidence that there is a plan to address the misconception

1 point, a misconception is identified or names, but it is not clear what the teacher plans to do to correct the misconception in the student’s mind

6.5 MATH CONTENT

1 point, there are no errors, or the errors that are made are minor and would not lead to students to develop a misconception

0 points, an error is made that will lead student astray creating a misconception or misunderstanding—for instance, when adding two integers take the sign of the large number leads to a misconception that negative numbers might be larger than positive numbers
ABSTRACT

Researchers believe that low-income ethnic and racial minority parents will choose private schools over public schools should voucher programs become prevalent in their school districts, as these parents are the least satisfied with their neighborhood public schools.

To assess parents’ attitudes toward school vouchers, I conducted focus group interviews with a total of 31 low-income Asian, African, African American and Latino parents in four groups of seven to eight parents. The parents interviewed for this research hold fairly positive views about the public schools their children attend, although they indicated that these schools need improvement in a number of areas. The parents in this study do not believe that their children are “trapped” in their neighborhood K-12 public institutions, as charter schools offer them an opportunity to choose schools. Based on the findings of this study, I offer some recommendations to make public schools attractive to all low-income ethnic and racial minority families.

INTRODUCTION

The current system of education whereby children are assigned to their neighborhood public schools has been under fire for quite some time. Friedman (1962), Coons and Sugarman (1978), Kozol (1991), Peterson and Hassel (1998) have charged the current system of neighborhood school assignment to be inadequate. To make their point about what they believe to be an inadequate system of education, these authors point to the declines in Scholastic Aptitude Test (SAT) scores; they compare the levels of student achievement in the United States to those of students in other industrialized countries. They also point to the educational inequalities between children of educated parents and those of the less educated and low-income families, which inequalities they believe are direct consequences of government school assignment policy. As Coons and Sugarman (1978) assess, the neighborhood school assignment policy “encourages the maintenance of a system in which school selection for the child is made out of total ignorance of the child’s wishes or special qualities” (p. 53). Rather than compelling children to attend the schools in their neighborhood, critics of this system would like to see that parents be given the opportunity to choose the type of school experience they (parents) think their children need. With school choice, they argue, the number of low-income ethnic and racial minority families who will be happy with their chosen environment will increase, low-quality schools will be forced out of business, and education will gradually improve in the broader sense of the word.

One type of choice proposed by advocates of school reform is a voucher plan. As Raywid (1995) explains, this type of choice is not to be confused with public school choice as they are not the same. While public school choice allows parents to choose schools within the public school sector, vouchers give parents the greatest freedom to choose either public or private schools for their children.

BACKGROUND

The idea to allow families to send their children to a school other than their neighborhood school dates back to 1776 with Adam Smith. Smith was the first to propose in his 1776 publication, Wealth of Nations that government give money directly to parents for the purchase of their children’s education. As Picus (1979) explains, referring to public school teachers, Smith believed that anyone paid from the public purse lacked the motivation for performance possessed by those in the private sector. Therefore, some means to introduce competition into the system was essential. As this author further explains, Smith’s idea was later promoted by Thomas Paine, in his 1792 publication The Rights of Man, and by John Stuart Mill in his 1859 publication, On Liberty. Like Smith, Paine and Mill believed that educational choice would promote competition and lead to the success and profitability of the best schools. Following Mill’s 1859 publication, the focus on educational vouchers diminished and resurfaced in recent
times when in 1954, four southern states, Virginia, Mississippi, Alabama and Louisiana invented their own voucher schemes in which public funds were provided to parents to send their children to “white academies” to avoid desegregation.

The first of the modern theorists to advocate a voucher program was economist Milton Friedman. In the 1950’s and 1960’s, as some parents became dissatisfied with the compulsory neighborhood school attendance policy referred to as the “One-Size-Fits-All” system, Friedman (1962) agreed with dissatisfied parents that public education is inefficient as it often “traps” poor families in poor school systems. Like the 1944 Servicemen Readjustment Act (or the G. I. Bill), Friedman (1962) argues, why not give families public monies so that they may send their children to any school of their choice, public or private?

As McCarthy (2000) observes, the idea of vouchers has political appeal because it reflects the ideal of American democracy and promises to offer more educational opportunities to disadvantaged children. As this author also points out, of all the reform ideas proposed to improve the current education system, “no topic is generating more debate among educators and politicians today than voucher systems to fund schooling” (Phi Delta Kappa, January 2000, p. 371).

STATEMENT OF THE PROBLEM

It is undeniable that from the 1950’s up until now, one of the most debated and unresolved educational issues is not only whether parents should be able to choose the school their children attend, but whether private schools should be included in their choice.

In light of the unresolved questions around a voucher system of education, the Carnegie Foundation (1992), Knight (1995), Ragsdale (1996) and Scafidi (1998) have explored parents’ attitudes toward school vouchers. These researchers found that, although many parents perceive public education in general as mediocre, most of them would not participate in a voucher program as they believe that their children’s academic needs are being met in their assigned neighborhood public schools, which they believe are convenient and safe. The results of these assessments are inconsistent with those by Krashinsky (1986), McDermott (2000) and McCarthy (2000) who found that the public in general has not made up its mind on the issue of educational vouchers simply because it may be bad economics and an unfair way to educate children.

The research studies reviewed for this paper investigated several aspects related to the issue of vouchers. However, one major problem these studies have in common is that researchers were concerned mostly with the views of European American parents and not with those of ethnic and racial minority families. This limited validity resulting from the failure to capture the views of low-income ethnic and racial minority parents might be due to two major factors: one is the under-representation of ethnic and racial minority parents in study samples, or an over-representation of European Americans in the population samples studied; the second factor is the failure on the part of researchers to recruit interviewers who share the same ethnic and racial background as ethnic and racial minority parents or guardians of students in their study samples.

The authors of the studies by the Carnegie Foundation (1992), Knight (1995), Ragsdale (1996) and Scafidi (1998) recognize their failure to assess the perceptions and feelings of low-income ethnic and racial minority parents toward school vouchers. This is evidenced by their assumptions that should voucher programs become prevalent in their school districts, low-income ethnic and racial minority parents, wherever they may be, will take advantage of voucher programs out of necessity and change their children’s schools from public to private. Furthermore, there is a belief among these researchers that ethnic and racial minority parents lack information about the quality of schools in their geographical areas, and because of this, the majority of these parents will take advantage of voucher opportunities, mostly for nonacademic reasons such as convenience, safety, or proximity of the chosen school to home and work.

Undoubtedly, researchers’ assumptions about ethnic and racial minorities and the reasons for their possible inclinations were based on the reactions of Mexican American parents,
the vast majority of whom participated in the 1977 Alum Rock (California) school district large-scale voucher experiment. As Goldhaber (1999), and Bridge and Blackman (1978) reported, in the 1977 Alum Rock school district voucher experiment, of the many Mexican American parents asked about the reasons for their participation in the voucher experiment, more than 70 percent of the program participants cited proximity of their chosen school to home as an important factor in their school choice decision. What this apparently means is that curriculum and instructional factors were less important to the majority of the Mexican American families who participated in the Alum Rock (California) voucher experiment.

RATIONALE

There are many reasons for my interest to investigate how low-income ethnic and racial minority families feel about school vouchers. Very little is known about the views of low-income ethnic and racial minority parents toward vouchers, whereas, as Witte (2000) explains, “most voucher programs have for their purpose to provide educational opportunities for poor families who would have had considerable difficulty placing their children in private schools” (p. 46). As Thomas and Clementson (1999) point out, “vouchers are still an educational experiment affecting one tenth of a percent of American schoolchildren. Only the state of Milwaukee, the state of Florida and the Cleveland, Ohio school district have large-scale voucher programs; polls show that most Whites are satisfied with their public schools and do not view vouchers as a fair way of educating children” (p. 47). Most importantly, all of the conclusions of the studies that investigate parental attitudes toward school vouchers indicate that low-income ethnic and racial minority families, wherever they may be, will participate in voucher programs and choose private schools over public schools for their children. One last and equally important reason for this study is that in previous studies that explored parental attitudes toward school vouchers, researchers employed the survey methodology. Jarrett (1993), Frey and Fontana (1993), Kruegger and Casey (2000), and Witte (2000) have found the survey methodology to be ineffective to determine people’s true perceptions and feelings about important and sensitive issues such as vouchers. As these authors explain, the survey methodology does not work well with members of minority groups as these groups are often reluctant to put their views about sensitive subjects on paper and send those views to people they do not know or never met. As Moe (2001) also indicates, although survey studies are helpful in giving us a sense of what is going on, such studies turn out mostly to be brief reports that simply describe how people have responded to a variety of survey items, thus, leaving the reader to make educated judgments on what the responses seem to mean. In other words, although survey data are of great importance in social science, attitude measures based on self-reports are not enough to convey human feelings. Rather, observable behavior such as facial expressions, tone of voice and body language is also needed for a true measure of attitudes.

RESEARCH QUESTIONS

This study seeks to find answers to three major research questions:

1) What are low-income ethnic and racial minority parents’ attitudes toward school vouchers?

2) Are low-income ethnic and racial minority parents inclined to transfer their children from public to private schools under a voucher system?

3) What are these parents’ reasons for school selection under a voucher system?

SIGNIFICANCE OF THE STUDY

The findings of this study, the phraseology that parents used to make school choice decisions inform school leaders about the levels of interest ethnic and racial minorities have toward school vouchers. Based on the findings of this study, school leaders would know the culture and values that drive low-income ethnic and racial minority parents, whether these parents view vouchers as a valuable response to their needs.

It is important for the educational community to know how low-income ethnic and racial
Knowing these parents’ feelings and the criteria they use to make school choice decisions give educational leaders the opportunity to reflect on their school programs from the perspective of low-income ethnic and racial minority parents in their districts. When school leaders know the attitudes and expectations of parents from different ethnic backgrounds, they make adjustments in their school programs to better address the needs of students and their parents. Subsequently, communication among teachers and administrators would be enhanced, and the connection between the school and ethnic minority communities would be strengthened.

Lastly, the findings of the study may help public school educators to develop, if necessary, a variety of strategies that would allow them to successfully compete with private schools. Knowing the concerns that Latinos, Asians, Africans and African Americans have about the schools their children attend, and addressing those concerns in a timely manner, public school leaders could have less fear of losing students to private schools should a state or federal voucher policy be enacted.

**METHODOLOGY**

This study is limited to low-income Asian, Latino, African and African American parents residing in the city of Lowell, a relatively revenue-poor school district in the state of Massachusetts, which has a large population of ethnic minorities, and where there are currently no voucher plans. By low-income I mean a wage earner who participates in a housing rental assistance program such as section 8 and/or whose children receive school lunch free or at a reduced price because his/her annual income does not exceed $28,000.00 for a family of three, $34,000.00 for a family of four, and $40,000.00 for a family of five as determined by the U.S. government (Letter to Household, National School Lunch/Breakfast Program, Secretary of Agriculture, 2002); by African I mean a new immigrant from a country on the continent of Africa. Other low-income parents who were not ethnic minorities were not considered for the study.

Focus group interviews were conducted during three months in the summer of 2002, to gather qualitative data about parents’ attitudes toward school vouchers. I selected a total of 31 (N=31) low-income ethnic and racial minority parents or guardians of children attending public schools. These parents were interviewed in four groups of seven to eight participants for 90 minutes. Of the 31 parents who agreed to participate in the study, seven were males (n₁=7) and 24 were females (n₂=24). Parents were presented with hypothetical situations and asked whether they would be inclined to transfer their children from one school system to another under a voucher program, and the reasons for their preferences for schools.

For each of the parent group selected for the study (Latino, Asian, African and African Americans), I recruited a moderator who shares the same ethnic and racial background as the study participants to conduct the focus group interviews. I performed the role of assistant to all moderators to whom I gave a script to follow. In my role of assistant moderator, I instructed each moderator to create an open and permissive atmosphere so that each group participant may feel comfortable enough to share his or her views freely. In the course of the focus group interviews, I audio-taped each of the sessions and took field notes.

Frey and Fontana (1993) have indicated that a moderator can assume at least two types of roles; a nondirective, passive role, and a directive or active role. As these authors explain, in the nondirective, passive role, the moderator employs unstructured questioning and asks questions to probe, offer reinforcement to keep the discussion going. The second role (as they explain), calls for the moderator or interviewer to be involved with the direction of the interview by administering a structured set of questions or by constantly keeping the group on track. For this study, following the recommendations by Frey and Fontana (1993), I chose the directive or active role over the nondirective or passive role. In other words, I gave each moderator a preplanned structured set of questions to ask and an outline to follow. One of the reasons for the choice of the directive or active role is to make sure that all the discussions are focused on certain topics and the groups are organized in their content. As Fowler and Mangione (1990)
have assessed, such role minimized errors in the data collection procedure.

As assistant to the moderators, my role also involved attending to the environmental conditions and logistics such as refreshment, sitting arrangement, childcare, and lighting. I made sure that distracting interruptions as well as confusions are minimized during the focus group discussions. It was my role to ask for clarifications during the group interviews to capture the true feelings of parents toward school vouchers. I synthesized, whenever appropriate, the ideas that emerged from the group discussions, in order to identify a common theme, a common concern that the group participants had. As Ephross and Vassil (1988) explain, the purpose for this is to reduce ambiguity, set the stage for broader discussion, and move the group forward to the next level of concern. At the end of each focus group session, it was my role to give a two-minute summary of the key points of the discussion and allow for further feedback from the participants. To make sure that my role and that of the moderators were clear in our minds prior to each focus group interview, I provided an outline of the purpose and rules of the focus group sessions for each moderator to follow.

**RELIABILITY AND VALIDITY OF THE STUDY**

In the course of the interviews, I paid close attention to the frequency and extensiveness of participants’ comments and considered only those comments that were most important for the study. Quotes or comments that specifically described parents’ experience with their public schools, and in which participants showed interest or passion were given more weight. As I analyzed each transcript, comments not relevant to school experience were set aside and reviewed later to see if these comments would fit into new categories. As author Knodel (1993) advised, after I analyzed the transcript independently, I used the “team approach” to review and summarize the collected data. To assure quality and reliability of the research findings, I involved each moderator in the reading of the transcripts, after which the moderators were asked to summarize the contents of the transcripts and then comment on my analysis. This procedure helped to minimize bias and subjectivity that might lead to unreliable conclusions. In the process of reviewing participants’ comments or statements of views, I categorized these and looked for differences and consensus within and between groups. As Knodel (1993) indicates, the extent to which consensus is found within and between groups about their expectations enhances the probability that the information collected is reliable.

**RESEARCH FINDINGS**

The major findings of this study show that the low-income ethnic and racial minority parents interviewed for this research hold positive views about the public schools their children attend. However, the Asian and Latino groups of parents in the study expressed a desire to participate in voucher programs and to transfer their children from public to private schools. These two groups of parents who indicated that they would participate in voucher programs and wish to send their children to private schools were recruited for the study through area churches. These parents represent 52% of all study participants. It is not surprising that their attraction to private schools is mostly based on religious education. Below is a summary of study participants’ responses to voucher questions:

**RESPONSES OF AFRICAN PARENT GROUP**

A total of seven (7) African parents participated in the focus group, six males and one female. Of the seven African parents who participated in the focus group interview, five stated that vouchers were not a good idea and that they were opposed to their use to choose schools, public or private for their children. These parents said they would not use a voucher, either full or partial to change the school their children attend.

Four categories of issues emerged from the focus group interviews with African parents to explain their views against school vouchers. These issues are:

a) Behavior and discipline, b) Transportation, c) High-performing neighborhood school, d) Academic competition.
Behavior and Discipline

All of the African parents interviewed believe that their children’s needs are being met in their neighborhood public schools. One of the very first issues they raised relates to behavior and discipline in the schools their children attend. Although there was a common agreement that their public schools are generally performing at an acceptable level academically, parents in this group believe that their schools would perform to the highest academic level if their leaders became stricter toward disruptive students. As they generally see vouchers as an inappropriate strategy for school improvement, all of the parents in this group offered their own strategies to improve schools and schooling. They all expressed a desire to use external sanctions (or punishment) on their children who behave poorly, without government interference. The African parents in the study believe their rights to discipline their own children have been taken away by government. Consider the quote below by one African parent:

Why can’t parents be allowed to correct their own children?
I think this would improve public schools. Not vouchers. Can you imagine a teacher telling a 7-year old to call 911 if his father corrects him?

The two (2) African parents who dissented from the majority position indicated that they might consider the use of a full and not a partial voucher to send their children to any school outside of their neighborhood, public or private. These parents indicated that they would consider a change only if a particular subject they would like for their children is not taught in their current public school.

Transportation

Another reason for which the majority of African parents in the study prefer their neighborhood schools is the fear that their children might miss school in the event they lack transportation. All the parents in this group were eager to know how their children would get to the school outside of their neighborhood or the town in which they reside in the event they choose a school elsewhere. The quote below by one parent is evidence of this finding:

Right now my children are picked up by a school bus. My car does not always work right. I won’t be able to drive him to school if I have to.

A third reason for which the majority of African parents prefer their neighborhood schools is to assure their continuity or survival.

Neighborhood Schools

The African parents in the study defended the need for neighborhood schools, as they fear the effects a voucher policy may have on their public institutions. This finding is based on the comment below:

If I use a voucher and take my children out of my neighborhood school, and other parents do the same, what if the school closes...?

The parents in this group do not want their schools to be closed due to possible low enrollment as a result of voucher programs, or public schools competing with private schools for students, although this is what voucher advocates have predicted and would like to see happen. Rather than leaving the public schools to market competition and think this would improve public schools, the parents in this group suggested academic competition among students and a student reward system similar to the system in their native countries that are former European colonies. There was a general agreement among African parents that academic competition and a student reward system would motivate students to learn and thus improve education.

It is good to choose, but if people think that vouchers will improve public schools because these schools will compete with private schools, I think that is false. Why not have students compete among themselves...?

The ways in which the African American parents in the study responded to the voucher questions is what I will now present.
RESPONSES OF AFRICAN AMERICAN PARENT GROUP

A total of eight (8) all-female African American parents participated in the focus group discussion. Of the eight female parents, seven opposed the use of vouchers. This represents the majority of the African American parents in the study. These seven respondents made it clear that they would not participate in a voucher program should such opportunity become a reality in their school district. As in the case of the African parents, African American parents believe that their children’s needs are being met in their neighborhood public schools. One (1) of the eight (8) parents in the group remained undecided over the use of school vouchers. The reasons for which the African American parents in the study opposed the use of vouchers are a) School ownership or Territorial Issue, b) Community school, c) Cultural diversity, d) Parental involvement, e) Social promotion, f) Charter schools, g) Hidden costs of private schools, and h) Behavior and discipline.

SCHOOL OWNERSHIP/TERRITORIAL ISSUE

There is a belief among the African American parents interviewed for this study that should they decide to send their children elsewhere, these children will be seen as intruders by others. Consider this statement:

We have excellent, top quality public Schools in the City of Lowell.
Would I send my child to another area? No. Because the child will be looked upon as you don’t live here. This is our school.

COMMUNITY SCHOOLING

The African American parents believe that it is a good practice to have their children attend the school in their community where they feel comfortable, and where the school is representative of the population that live in that community. As one parent indicated:

I want my child to go to school in our community where she feels comfortable. How would anyone feel being the only black kid in the class? That was my case in elementary school a long time ago and I didn’t like it. There was no one I could relate to.

CULTURAL DIVERSITY

Parents believe that the cultural diversity in public schools is something that their children can benefit from.

I like the diversity in the Lowell Public Schools. If you go to every classroom in Lowell, you might see an Asian sitting next to you. You might see a Latino or an African. And we all see each other as being the same.

PARENTAL INVOLVEMENT

As in the case of African parents, there was a general agreement among the African American parents interviewed that greater parental involvement, not vouchers, is the most appropriate strategy for school improvement. As one group participant stated:

As a parent, I know my child is smart. He is learning something. It is up to me to work with him. The school cannot do everything.

SOCIAL PROMOTION

As a definition, social promotion is the act of passing students to the next class or grade even though they have not mastered basic materials. All of the parents in the African American group would like to see children who perform below academic standards held back. These parents believe that having under-performing children repeat their grade would motivate all students to learn and thus improve their education.

They are talking about improving schools? Here is something they can do. Hold kids back if you know they have not learned what they should.

As a reason why she would not use a voucher and send her children to a private school, one parent who is opposed to social promotion indicated that private schools are where social promotion is practiced the most.
CHARTER SCHOOLS

The issue of charter schools was brought up by one parent whose children attend a charter school. This parent stated that vouchers are not necessary for her as charter schools offer parents an opportunity to choose schools outside of their neighborhood.

Basically I chose the school that my children go to now. It is a charter school. The ones I picked before are full, and I had to wait.

By definition, a charter school is an independent public school that is supported by state funds but is exempt from many regulations. Unlike the current system of compulsory neighborhood school attendance, charter schools accept all students regardless of their place of residence.

HIDDEN COST

One important reason for which most African American parents opposed private school is these schools’ hidden costs. Most of the African American parents interviewed feared that even with tuition paid in full by government voucher, private school administrators might still solicit financial support from parents for some reasons. As one parent indicated:

...That’s another thing. You know that even with a full voucher they will still ask parents for money for this and for that.

Yes. We want this type of paper only, not that type. And number 2 Pencils only.

The parents in this group fear that private schools may require certain school items or money for extracurricular activities that they may not be able to afford.

BEHAVIOR AND DISCIPLINE PROBLEMS

The African American parents interviewed believe that their public schools would perform to the highest academic standards if their administrators were stricter with disruptive students as private school administrators are with their students, and if parents had the authority to discipline their children.

There is no big difference between public schools and private schools. You see, the only difference is that Catholic children behave or they are getting out. They don’t care how much money you are paying. You are getting out.

I think parents should be able to discipline their children without the system stepping in...

I will now present the Asian parents’ responses to voucher questions.

RESPONSES OF ASIAN PARENTS

Eight (8) Asian parents (seven females and one male) participated in the focus group discussion. All of the eight (8) Asian parents who attended the focus group discussion thought vouchers were a good idea and that they would participate in such programs to change their children’s current schools. Although these parents indicated that their children’s academic needs are being met in their current public schools, they all stated that they would use a full and not a partial voucher to change their children’s schools from public to church-related private schools. The Asian parents interviewed based their decisions to participate in voucher programs on several factors: a) School safety, b) Dress code/school uniform, c) Zero tolerance policies of private schools, and d) Religious education and school size.

SCHOOL SAFETY

All of the parents in the study believe that the public schools their children attend are not safe and that private schools are safer and much more orderly. The Asian parents were concerned with the lack of control of students in public schools, although they all believe that there has been a substantial improvement in this area since the 1980’s.

I want to use vouchers.
I like private schools because not too much fights in private schools.
Before, like in 1980, gangs, fights, drugs. All Cambodian parents are afraid. Everybody is afraid. The children are afraid too.

**Dress Code/School Uniform**

All of the parents in the study indicated that they prefer private schools because of their dress code. As their comments show, the parents in this group associated dress code with discipline.

Private schools have uniform. They have discipline. Kids don’t fight...

**Zero Tolerance Policies of Private Schools**

All of the Asian parents in the study pointed to the strict discipline of private schools as their reason for their preference for these schools. As they indicated, zero tolerance policies give parents peace of mind.

In private schools, kids behave good. No fight. If you behave bad you don’t come back...parents don’t worry...

The parents in this group indicated that they would participate in voucher programs and send their children to a church-related school for religious education. As their comments imply, religion instills self-discipline and respect in children, which they believe renders the job of parenting much easier.

I want my kids to learn religion. The children don’t fight in private schools because they learn religion. They respect.

The last factor that the Asian parents considered important is school size. All of the Asian parents in the study indicated that the small size of private schools makes it easier for school officials to control or monitor children’s behavior closely.

Private schools are small. Public schools have too many kids and nobody can watch them. They cause trouble and they don’t go to jail in public school. They come back to school the next day.

The Asian parents in the study do not believe there is a difference in terms of academics between public schools and private schools.

The voucher decisions by the fourth and last group of parents in the study and the reasons for these parents’ inclinations are what I will now present.

**Responses of Latino Parents**

A total of eight (8) all-female Latino parents participated in the group discussion. As in the case of the Asian parents, all of the eight female Latino respondents indicated that they would participate in voucher programs should such opportunity become available in their school district. As in the case of the Asian parents, all of the parents in this group indicated that they would use a full and not a partial voucher, so that they may send their children to private schools. The Latino parents based their willingness to participate in voucher programs on factors such as: a) Zero tolerance policies of private schools, b) Dress code/school uniform, c) Student motivation, d) Homework. These factors as identified by the Latino parents are presented as follows:

**Zero Tolerance Policies of Private Schools**

The parents in this group indicated that they prefer private schools because of their zero tolerance policies with regard to bad behavior such as children’s lack of respect of persons older than them. As some of the parents commented,

...In private schools, the children respect. They teach them how to do that.

**Dress Code/School Uniform**

The Latino parents in the study said they were attracted to school uniform, the dress code of private schools, which they believe promotes discipline. As one parent asked:

Why they don’t have uniform in public schools? In private schools
they have uniform. I think uniform helps with discipline.

**Student Motivation**

The parents interviewed indicated that the public schools their children attend have more programs than private schools. However, public school teachers are not doing a good job at motivating students to take advantage of these programs. As one parent explains:

Lowell public schools have good programs. Everything is there. Encourage students. Some need encouragement. But teachers discourage them.

**Homework**

The Latino parents in the study believe that their children are not being challenged enough, although a variety of good academic subjects are available in the public schools.

As some parents pointed out:

My son is bored. Not enough homework. He needs to be challenged to learn more. Not all students have homework in public schools. Honor students have more homework.

This researcher noted a resistance on the part of parents to compare the schools their children currently attend to other public schools, as they believe there is no considerable difference among the public schools in their district, nor is there a clear line that separates public schools from private other than discipline.

**Data Analysis: A Summary and Analysis of Research Findings**

All of the four parent groups interviewed raised a number of issues or concerns that are relevant to the politics of vouchers. The African American group was the most vocal, although all of the parents in the study were eager to talk about voucher programs as a way to run their public schools.

The major findings in this study seriously question the assumptions that some researchers hold about vouchers and low-income ethnic and racial minority parents. As it has been seen, the parents interviewed for this research hold positive views about the public schools their children attend, although two groups of parents, the Asian and Latino groups expressed a desire to participate in voucher programs and transfer their children from public to private schools.

The African and African American parents in the study tended to strongly support the concept of a community education for their children. Not only do these parents stated that the neighborhood schools belong to them, but they also indicated that there are benefits in the diversified student body that exists in public schools. The parents who supported the concept of a community education were recruited through agencies other than churches. These parents represent 48% of all study participants.

An interesting finding of this study that is consistent with the arguments against vouchers is that African and African American parents believe that the public schools belong to the public and these can be improved without vouchers (Raywid, 1995; Cookson, 1996; Phi Delta Kappa, April 1998). In other words, although their public schools are performing well, parents believe that certain improvement programs must be considered and implemented, and this can be done without vouchers.

**Summary and Conclusions**

This study has answered the three research questions and shed some light on the assumptions some researchers have about low-income ethnic and racial minority parents and vouchers. Based on the findings of this study, a number of conclusions can be drawn. The first is that the minority parents interviewed are satisfied with the academic performance of their neighborhood public schools, contrary to some researchers’ assumptions about these parents. The parents in the study did not feel they are locked out from exercising their rights to choose, as they believe that charter schools offer them an opportunity to choose schools for their children. Furthermore, when parents talk about zero tolerance policies, dress code, school safety, class or school size as reasons for school selection, it is clear that academics and learning are on their minds. The reason for this is that in
most cases, for learning to occur, some of these concerns may need to be addressed by school leaders.

**IMPLICATIONS FOR POLICY AND PRACTICE**

The findings of this study provide an opportunity for school leaders and policymakers to better understand the attitudes low-income ethnic and racial minority parents have toward school vouchers. The ideas that emerged from all the focus group interviews show that when they are given the opportunity, low-income ethnic and racial minority parents can contribute to school improvement efforts; they can work in partnership with school leaders to “fix” the problems of schools. The multiple issues or concerns raised by the parents in this study can be helpful to some educators who wish to consider parental concerns in their conduct of school affairs, especially when these parents know the areas where public schools are lacking.

It should come as a relief to all public school leaders and policymakers, particularly those in the district where this research was conducted, that the low-income ethnic and racial minority parents interviewed for this study are satisfied with the education their children receive in public schools. This may not be good news for voucher advocates who maintain that public schools are inadequate and that they need to compete with private schools in order to improve.

**SUGGESTIONS FOR FUTURE RESEARCH**

Although this study solicited low-income ethnic and racial minority parent-volunteers to participate in focus groups so that their attitudes toward school vouchers may be explored, it lends itself to further investigation. Using the same methodological approach employed in this study, another researcher could explore the views of low-income ethnic and racial minority parents in geographical locations where there are no charter schools. It may be that the parents in this study prefer their neighborhood schools because charter schools offer them an opportunity to choose schools for their children. Parents’ reasons for school preference may vary from district to district. A set of factors that influence parents’ decisions in one district may not be identical to influential factors in another district.

Low-income ethnic and racial minority parents who had a chance to learn about school vouchers and are well informed about how they work could be considered by another researcher. The parents in this study were uninformed about school vouchers prior to this research. As a result of this, their opinions may be a function of whatever considerations came to their minds during the focus groups. Parents’ considerations may vary depending how well they know about vouchers. Furthermore, the Asian and Latino parents in this study may have favored vouchers because of their church or religious affiliation. Based on this, another researcher could conduct focus groups with Asian and Latino parents who are not Christians. African and African American parents who are Christians may be interviewed as well. It may be that the African and African American parents in this research supported the concept of community education because they were recruited through agencies other than churches. In regards to gender, it is true that more females than males volunteered in this study. Another researcher could conduct focus groups with equal representation of male and female parents.

**References**


Modeling plant growth with algebra and trigonometry is an interesting, relevant, real-world mathematical application. When used with graphics software, the models presented here lead to fascinating and lifelike images. The models may be used in a high school or college math course to help students understand how basic assumptions about plant growth lead to the golden ratio and accurate plant-growth simulations. With a computation and graphics system such as Mathematica, students can experiment, explore, and discover how varying a small number of parameters leads to a wide variety of simulated plant forms. The Mathematica code presented here can be easily modified for experimentation and easily rewritten for use with other math software packages such as Maple and Matlab.

Palm trees grow with a leaf pattern or phyllotaxis that is found throughout the natural world. Plants grow from groups of cells called meristems located at the ends of branches. From a meristem, new cells sprout into leaves, flowers, fruit, or branches at points along a spiral where the ratio of the angles formed by consecutive sprouts is a fixed constant. Spiral growth has evolved over many generations to maximize the total space for each part of the plant so that leaves have the maximum exposure to light, water and air; flowers have the maximum exposure to pollinating insects; and branches have maximum space to produce more leaves, branches, and flowers. Spiral growth occurs as a result of elongated and/or radial branch growth, meristem rotation, and a spiral growth rule where the ratio of the clockwise to counterclockwise measured angles formed by any two consecutive sprouts is a fixed constant.

To model spiral growth, assume that the sprout positions are projected onto a perpendicular cross section of the branch. Then any two sprouts form an angle with its vertex at the center of the branch. The notation used here to denote the measure of a projected, centered, counterclockwise-measured angle from, for example, sprout 1 to sprout 2, is \( A_{12} \). Using this notation, and assuming the meristem is rotating in the counterclockwise direction, the spiral growth rule can be described as follows (see Figure 1). After sprout 1 forms, the meristem rotates to the sprout 2 position where \( A_{21} \) divided by \( A_{12} \) is a certain constant. This constant equals \( A_{12} \) divided by \( A_{11} \) (the measure of one full revolution). After \( n \) sprouts have formed, \( A_{(n+1),n} \) divided \( A_{n,(n+1)} \) is the same constant.

Spiral plant growth is based on two equivalent assumptions that can be described as follows. Assume a sprout appears at point 1 in Figure 1. With the meristem rotating in the counterclockwise direction, the next sprout appears at point 2. Following the spiral growth rule, the ratio of angle \( B \) divided by angle \( A \) equals the ratio of angle \( A \) divided by angle \( A+B \) (one full revolution). Equivalently, assume a new sprout appears at the point where the angle from the second-most-previous sprout to the new sprout divided by the angle from the most-previous sprout to the second-most-previous sprout is a constant ratio. Either assumption generates the same sequence of sprout points.

The spiral growth rule can be written as

\[
\frac{B}{A} = \frac{A}{360} \tag{1}
\]

where \( A \) and \( B \) are the measures of the angles between sprouts 1 and 2 in Figure 1, and where the measure of the full revolution \( A+B \) is 360 degrees.
Then \( B = 360 - A \), so Equation 1 can be written as

\[
\frac{360 - A}{A} = \frac{A}{360} \quad \text{Equation 2}
\]

To find the spiral growth ratio, solve Equation 2 for angle \( A \). That is, solve

\[
A^2 + 360A - 360^2 = 0 \quad \text{Equation 3}
\]

Using “+” in the quadratic formula, one solution of Equation 3 is

\[
A = 360\left(-\frac{1 + \sqrt{5}}{2}\right) \approx 222.5 \quad \text{Equation 4}
\]

Angle \( A \) is called the golden angle. Using \( A \), the spiral growth constant, or the golden ratio, is

\[
\frac{A}{360} \approx 0.618 \quad \text{Equation 5}
\]

As the spiral growth process continues, the 3rd sprout is located so that the ratio of angle 3-to-2 divided by angle 2-to-3 equals the ratio of angle 2-to-1 divided by angle 1-to-2. See Figure 2.

That is,

\[
\frac{A - C}{B + C} = \frac{B}{A} = \frac{A}{360} \quad \text{Equation 6}
\]

If the ratio of the clockwise to the counterclockwise-measured angles between any consecutive pair of sprouts is the golden ratio, then the angle from one sprout to the next is the golden angle \( A \).

It is not immediately obvious from looking at spiral growth plants that a sprout occurs at every golden angle of meristem revolution. What makes the process misleading is that the observer sees only about one half of the leaves and/or branches around the trunk at any one time. The best way to fully understand the spiral growth process, however, is through experimentation with computer graphics software.

To simulate spiral growth, assume the right circular cross section of a meristem has radius 1. Assume sprout 1 is located on the far right side of the trunk with respect to the line of sight through the center of the trunk. Also assume the origin of the line-of-sight axis is at the center of the trunk. Then, the sine of the counterclockwise measured angle from sprout 1 to a new sprout is the projection of the new-sprout position onto the line-of-sight axis (the vertical axis in Figure 3). Moreover, the cosine of the angle is the perpendicular displacement of the new sprout from the line of line-of-sight.

A spiral growth pattern can be simulated with the following Mathematica code which generates one sprout at approximately every .618 of a revolution around a unit circle.

\[
A = 2\pi \left(\frac{5^{0.5} - 1}{2}\right)
\]

\[
T = \text{Table}\{\text{Point}\{\cos[n*A], \sin[n*A], n/200\}, \{n, 1, 200\}\};
\]

\[
\text{Show}\{\text{Graphics3D}\{\text{AbsolutePointSize}[6], T]\}\}
\]

In the above code, the golden angle \( A \) is computed and a table called \( T \) is created. By letting \( n \) take on integer values from 1 to 200, and using \( n*A \) as the argument of cosine and sine functions, two hundred \((x,y,z)\) sprout points at integral multiples of the golden angle are generated and stored in \( T \). For each point, the \( z \) coordinate is computed from the iteration number \( n \) and represents the elongation or height of the sprout on the trunk. Note that the iteration
number is scaled by a factor of 1/200 to prevent the image from being too tall. Finally, a 3-D graphic image is created and displayed. The graphics output, showing simulated sprout points around a palm trunk, appears in Figure 4. Students can experiment with the above code by changing the value of A to see how Figure 4 changes. Hint: try A=.5 or A=.8.

To create and display sprout locations the way plants are usually seen — on one side only — the following Mathematica code can be used.

\[
T = \text{Table}[\text{If} \left[ \sin(nA) < 0, \{\cos(nA) - n/300, n\}\right], \{n, 1,120\}]; \text{Show}[\text{Graphics}[\{\text{AbsolutePointSize}[12], T\}], \text{AspectRatio}\to 4]
\]

With the above code, table T contains \((x, y)\) sprout points. An 'if' statement is used to select only sprout locations on the viewer's side of the trunk. The side-to-side displacement from the line of sight and the iteration number are stored in the table. Note that a small linear term is subtracted from the side-to-side displacement to make the trunk lean to one side. An aspect ratio of 4 is used to stretch the graphics to appear more tree-like. The simulated phyllotaxy of the palm is shown in Figure 5 next to a photo of an actual palm trunk. Experimenting with the above code reveals that increasing the linear term produces vine-like twists in the trunk and that the perspective of being very close to a palm trunk can be created by replacing \(<0\) with \(<-.5\).

Few modifications of the above code are needed to create a 3-D spiral growth image. In the Mathematica code below, three hundred \((x,y,z)\) points are created. Again, only the points closest to the viewer are displayed. The x and y coordinates are scaled with the quadratic polynomial \((-80-n)(308-n)\) to approximate the varying radius of a spiral growth plant such as a pinecone, and the z coordinate is scaled by 300 to elongate the image.

\[
T = \text{Table}[\text{If} \left[ \sin(nA) < 0, \{-80-n)(308-n)\sin(nA), (-80-n)(308-n)\cos(nA), 300n\}\right], \{n, 1,300\}]; \text{Show}[\text{Graphics3D}[\{\text{AbsolutePointSize}[8], T\}], \text{ViewPoint}\to \{3,1,1\}]
\]

Changing the scaling polynomial creates interesting plant shapes, and changing the 'viewpoint' position gives new perspectives. Output from the above code is shown in Figure 6.

If sprouts emerge at radially-increasing distances from the center of meristem rotation rather than at elongated points along a branch,
the resulting spiral growth has a pattern common to flowers, pinecones, and many other plants. To create and display radially increasing sprout locations, the following Mathematica code can be used. In the code, \((x,y)\) points are computed at integral multiples of the golden angle and at increasing distances from the origin.

```mathematica
T = Table[Point[{n*Cos[n*A], n*Sin[n*A]}], {n, 1, 150}];
Show[Graphics[{AbsolutePointSize[8], T}], AspectRatio->1]
```

Output from the above code is shown in Figure 7 next to a photo of the end of an actual pinecone.

By combining the trunk pattern of Figure 5 with the radial pattern of Figure 7, the image of a flower can be created. The Mathematica code is shown below and its output is shown in Figure 8. Note that a palm tree trunk pattern is compressed into a stem keeping the diameter of the trunk small compared to the diameter of the flower head,

```mathematica
T = Table[If[n<125, {Cos[n*A]+n^2/2000, n}, {(n-140)*Cos[(n-140)*A]/6+14, (n-140)*Sin[(n-140)*A]/4+160}], {n, 1, 300}];
Show[Graphics[{AbsolutePointSize[2], T}], AspectRatio->3]
```

Spiral growth is found in different forms throughout the plant kingdom. Structural differences between plants are due to the rate at which branches elongate and the rate at which the radii increase during each meristem revolution. Plants such as cabbage, lettuce, and brussels sprouts exhibit a small amount of elongation for each meristem revolution which is why their sprouts (leaves) grow tightly together. On the other hand, plants such as ivy elongate rapidly for each meristem revolution with the result that their leaves are far apart.

**EXERCISES**

1. Spiral growth patterns of real plants are not perfect in part because of stresses from the environment while the plants grow. To simulate plant growth in a stressful environment, add a stochastic term such as Random[] to one or more of the coordinates in one of the above Mathematica procedures.

2. Using the proportion

\[
\frac{B}{A} = \frac{A}{360}
\]

where \(A\) and \(B\) are the angles between sprouts 1 and 2 as in Figure 1, show that the two spiral growth assumptions given in the article generate the same sprout points.

3. Referring to Figure 2, show that, \(A-C = B\).

4. Write a Mathematica program that shows the positions of sprouts along a trunk that are \(k\) sprouts apart. Demonstrate that if \(k\) is a Fibonacci number (e.g. 8, 13, 21), the sprouts fall along a line that becomes increasingly parallel to the trunk as larger Fibonacci numbers are used. Relate this phenomenon to the spiral growth rule described in exercise 2.

5. Demonstrate that \(-360^\circ\) divided by the golden ratio is a solution to Equation 3.
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2. Use double spacing with one-inch margins.

3. For references, diagrams, etc. follow the style described in the Publication Manual of the American Psychological Association (APA), Fifth Edition.

4. Paper length must not exceed 30 pages, including pictures, tables, figures, and list of references.

5. Paper must be received by November 15, 2005.

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