The Impact of Preservice Teachers on the Mathematics Achievement and Attitudes of Elementary Students at a Colorado School

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Abstract

A range of factors has impinged on the provision of teacher education programs in the US over the last decade. Largely emanating from governmental demands for increased accountability, they have included the setting of standards for student achievement, proof of program impact, and state and national testing. These legislative reforms and school district concerns initiated changes in field experience at a western USA university, which adhered to a professional development school philosophy. During the final student teaching experience, preservice teachers were asked to teach mathematics to a small group of students for a 3-month period. The preservice teachers took control of every aspect of the groups’ mathematics instruction. Elementary student participants were selected on the basis of pre-tests given to the entire school population. The impact on elementary student achievement and attitudes, and preservice teacher development of pedagogical knowledge and understanding was investigated as part of this study. This paper focuses on the impact on elementary students. Data analysis revealed significant achievement gains for all of the elementary students, as well as positive changes in attitudes towards mathematics.

Background

As society becomes more complex, pressure for educational change comes from the business community, professional organizations, and more recently, from government legislation (Becker & Jacob, 2000). One tool of reform has been the development of educational standards. Assessment of these standards has in turn led to state level tests. Not only are standards being set for student achievement but there is a trend for teachers to be held directly accountable for this achievement as measured by these state tests (Bracey, 2000). Schools are changing both curriculum and instruction in an effort to improve these test scores (Brawdy & Egan, 2001).

The ability of teacher education programs to produce quality teachers is continually being evaluated. Many states have developed performance standards for teacher certification and some states require evidence of student achievement as a result of preservice-teacher intervention National Research Council (2001). Title II, part of the Higher Education Reauthorization Act of 1998 amendment, legislated reporting of preservice-teacher performance by universities.

Teacher education programs are being restructured in response to these demands (Quatroche, Duarte, Huffan-Joley, & Watkins, 2002). According to SenateBill 99-154, a measure of preservice teacher performance is the impact their instruction has on student performance. In addition, school districts are beginning to demand information concerning the contribution of preservice teachers to student learning. Universities and schools are beginning to search for mutually beneficial programs that assist with preservice teacher development, assess
proficiency and also tangibly benefit school students. Increased accountability has caused schools to re-examine current programs and use of resources. School districts are requiring evidence of student learning as a result of preservice teacher programs in the schools.

Mathematics is one of the disciplines being tested by the State of Colorado, and there is significant interest in student performance and attitude in this discipline. One of the performance-based assessments adopted by Mountain University (MU), a Western state university, examines preservice teachers’ instruction and assessment in elementary mathematics. There was a genuine need to investigate the impact of the elementary mathematics PBA on the development of preservice teachers and their students. This paper is mainly concerned with the achievement and attitudes of elementary students taught by preservice teachers.

**Literature Review**

**Effective Mathematics Instruction**

**National Standards**

The National Council of Teachers of Mathematics (NCTM) was one of the first national groups, in 1989, to develop a comprehensive set of standards for both students and teachers. The revised document in 2000 addressed pedagogical principles in equity, curriculum, teaching, learning, assessment, and technology. In addition, main content areas, including number and operations, algebra, geometry, measurement, data and analysis, problem solving, reasoning and proof, communication, connections, and representation, are considered by grade-level groupings.

National standards have been further refined according to each state’s interpretation and on the basis of local needs. Forty-nine states have established mathematics standards Council of Chief State School officers (2000). The Colorado Department of Education (CDE) Model Content Standards for Mathematics identify the need for students to be mathematically literate. The main goal is to enable students to understand and use mathematics that will be needed for citizenship and employment in the 21st century.

**What is the Current State of Mathematics?**

Many people believe that the 1989 NCTM standards heralded the biggest mathematics reform of the 20th century (Kaufman, 2001). Despite all reform efforts, recent studies indicate that mathematics taught in elementary and middle school mainly consists of basic arithmetic tasks that use memorization and repetition (Kaufman). According to Kaufman, U.S. students perform adequately on basic computational tests but have difficulty in applying mathematical knowledge to problems.

Data continues to give mixed messages concerning U.S. student achievement. The National Education Association (NEA) states that current data indicates promising performance in mathematics by U.S. students (1998). Assessments have indicated a slow but steady gain in achievement for 9-year-olds and 13-year-olds National Science Foundation (NSF, 1998). The performance of 17-year-olds is however, close to that of 1973. Following the release of A Nation at Risk, the majority of states increased mathematics requirements for graduation. International comparisons show that U.S. students have “much room for improvement in mathematics” (NEA, p. 2).

Proficiency is an ambitious goal, and the United States will never reach it by continuing to change slowly through education policy, the Kaufmann report states (2001). In recent years, many states and school districts have raised academic standards in mathematics, introduced
new assessments, and offered teachers professional development opportunities. But these efforts have been inconsistent across different districts and states. (NRC report as described by Kaufman).

According to Good, Mulryan and McCaslin research continues to highlight significant problems in mathematics education (1992). Many teachers do not present mathematics in ways that are meaningful for their students. Furthermore, it is apparent that an inordinate amount of time is spent on low-level procedures rather than on reinforcing conceptual understanding.

Mathematics Education Reforms
Reforms in mathematics education have been under discussion for many years. The National Council for Teachers of Mathematics (NCTM) maintains that all students are capable of learning reasonably complex mathematics skills (1998). According to Battista “traditional instruction ignores student’s personal construction of mathematical meaning, the development of their mathematical thought is not properly nurtured, resulting in stunted growth” (1999, p. 430).

Researchers reinforce the importance of real understanding of mathematics, by emphasizing the need for students to make connections between ideas, facts, and procedures based on previous knowledge and newly established relationships (Hiebert, & Carpenter, 1992). Acknowledging students’ previous experiences and creating meaningful opportunities for new mathematical connections to develop can lead to more complex understanding. Consequently, students are more likely to remember what they have learned and to transfer the knowledge to new problems (Hiebert, 1992).

Student Achievement

Main Influences
As explained, teacher effectiveness accounts for about one-third of variance in student achievement (Hattie, 2003). A longitudinal study conducted over eight years by the Center for Research on the Education of Disadvantaged Students (CDS) found that school and teacher effects accounted for 24% of student achievement (CDS, 1992). According to Hattie, students account for about 50% of the variance. Student ability, disposition to learn, and affective and physical attributes jointly compose the student factor in the meta-analysis. In addition, home, schools, principals, and peers each account for 5–10% of the variance of factors affecting student achievement.

A recent study conducted by the Public Policy Institute of California used a large database of student, school, and district data to investigate factors that impact student achievement (Betts, Zau, & Rice, 2003). Resource allocation (including class size and teacher training) and achievement were analyzed according to socio-economic-status (SES) groupings of schools. Students at lower SES schools received fewer resources and scored lower on reading tests. Student factors impacting on achievement were student attendance, average scores of peers, and other classroom-peer effects. Although some effects were connected to teacher education, certification, and experience, the impact for these factors was not totally clear (Betts et al., 2003).

Jacob and Lefgren found inservice-teacher training in the Chicago public school system to have no statistically significant impact on elementary student achievement in reading and mathematics (2002). One reason posited by the researchers for the results was the mismatch between content of the training and curriculum needs. The results are consistent with other
U.S. studies of the effect of inservice teacher training on student achievement (Jacob & Lefgren).

Darling-Hammond cites National Assessment for Educational Progress data that demonstrates clear connections between Year 8 performance, in mathematics and science tests, and teacher training (2003). This research determined that the following teacher-related factors are influential in student achievement: (1) subject-matter training, (2) preservice teacher education and professional development in diversity, (3) training in teaching higher-order skills, and (4) teacher education or professional development in laboratory skills and hands-on manipulatives.

The above examples highlight the need to contextualize study results. While it is possible to generalize some research findings, many educational studies are dependent on local environmental factors. It is important to screen study results through a filter of methods used, number of participants, length, and location.

Class Size
Conflicting research findings in numerous studies make conclusions concerning class size difficult to make. Analysis procedures in some studies have failed to separate class size adequately from other student achievement influences. Analysis in Hattie’s study indicated no significant link between class size and student achievement. Hattie claims that in many recent studies, where connections between class size and student achievement have been determined, influencing factors have been subdivided too much (2003). Good et al. claim that “grouping does not in itself improve lessons” (1992, p. 168). While some research has found connections between student learning and small groups, most studies have failed to investigate student thinking and problem solving (Good et al.).

Betts et al. found evidence of a relationship between class size and achievement for elementary students but not for middle school or high school students (2003). A longitudinal study in Tennessee, the Student Teacher Achievement Ratio Study (STAR), determined four clear relationships between class size and student achievement (Student Achievement Guarantee in Education (SAGE), 2002). According to study data, of students at 79 schools, those in small classes: (a) graduate on time – 72% of students, versus 66% from regular classes, (b) complete more advanced mathematics and english courses, (c) complete high school – 19% dropped out, versus 23% from regular classes and (d) graduate with honors.

Research from Wisconsin’s Student Achievement Guarantee in Education (SAGE) also seems to confirm the effectiveness of class size reduction on student achievement (Waymack & Drury, 1999). Study data indicated that the achievement gap between African-American and white students narrowed in small classes. In addition, “students in small classes displayed more initiative, greater effort toward their school work, and less disruptive and inattentive behaviour in class, even after they had returned to normal-size classes in the fourth grade” (Waymack & Drury, p. 3).

According to Good et al. (1992) small groups are not the utopia of instruction that some educators had predicted. Simply placing students in a small group does not guarantee improved performance. Teachers must consider a variety of pedagogical factors including instructional methods, relevance, social issues, interest, and management.

Slavin determined that group goals and individual accountability are both important in small-group success (1990). In addition, giving students opportunities to tutor each other can be beneficial for older students (Good et al., 1992). Research is cited however, that found that tutoring by second and third grade students in small groups was not associated with achievement gains.
Mulryan’s research indicated links between student engagement and small groups (1989). She notes however that this finding is somewhat dependent on students’ level of achievement. Other researchers have stated that low achievers may be reluctant to ask questions in groups because they do not want to appear stupid (Good et al., 1992). Research concerning the relationship between class size and student achievement remains an ongoing need.

**Learning to be a Mathematics Teacher**

The last few decades have seen a renewed interest in preservice teacher education in mathematics. According to Brown and Borko, however, reports indicate that many teacher education programs do not prepare students to teach mathematics according to the reform movement (1992). Ball determined that many preservice teachers have inadequate knowledge of the “underlying principles” of mathematics (1988).

It is important to realize that teacher education is not the beginning of students’ exposure to teaching. “In fact before they take their first professional course, future mathematics teachers have already clocked over 2,000 hours in a specialized ‘apprenticeship of observation’ (Lortie, 1975, p. 61) which has instilled not only traditional images of teaching and learning but also shaped their understanding of mathematics” (Ball, 1989, p. 1). The role of methods courses in addressing beliefs, ways of thinking, content, and pedagogy is daunting given the small amount of time allowed for this learning.

**Future Course Directions**

A recent NRC report details the necessary components of a preservice elementary mathematics teacher education program. “Universities should create programs or courses that emphasize thorough knowledge of mathematics and of processes through which schoolchildren come to understand the subject” (Kaufman, 2001, p. 2). Vacc and Bright report that when mathematics methods courses are consistent with field experience, preservice teachers are more likely to alter their beliefs (1999). In their research, preservice teachers adopted a more constructivist philosophy with regards to teaching mathematics.

Taylor discusses the impact of standards on preservice teacher education in mathematics (2002). Suggestions are given for students to create lessons using information from current research data. Taylor posits that programs should “immerse the preservice teachers in both theory and practice” (p. 138). Other educators suggest using an inquiry approach to learning for preservice teachers (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Lampert and Ball discuss the role of methods classes in preparing preservice teachers as “agents of change” in mathematics reform (1998). Many current teacher education programs only prepare students to teach in current schools with little consideration given to the future. Lampert further iterates beliefs that preservice teachers must become part of a professional community (1990). Teacher education must incorporate mathematics reform and respond to the changing needs of students (Graham & Fennell, 2001). This implies that there is a role for methods courses in assisting preservice teachers to become knowledgeable and reflective practitioners.

**Field Experience**

While research provides evidence supporting the value of good field experience, poorly planned internships or experience at schools with philosophies that differ significantly from the university may have a negative impact (Gallego, 2001). Promise of positive results is seen in programs that make connections between field experience and university courses. Szabo, Scott, and Yellin describe a program that integrated a classroom management class with a one
day a week field experience (2001). The preservice teachers in this study became more empowered through this integrated approach.

Field experience has frequently presented preservice teachers with a traditional teacher-centered pedagogy (Mewborn, 2001). To address this concern, the University of Georgia developed a field experience program that directly supported the mathematics methods class. Preservice teachers were given the opportunity to work closely with an individual student in mathematics. Mewborn explains that, in this way, the management concerns were lessened and the preservice teachers were able to reflect critically on the intricacies of pedagogy. Follow-up discussions were conducted in the pre-requisite methods class. In addition, supervisors of the preservice teachers later observed an increased readiness to teach mathematics.

Field experience has more impact on a preservice teacher’s self-efficacy than methods courses do (Hughes, 1999; Lowery, 2002). Growth and development of preservice teachers during field experience is enhanced through opportunities for discussion and reflection (Lowery, 2002). It is becoming increasingly clear that the benefit of field experience is closely related to the nature of the school/university relationship.

**Impact of Preservice Teachers on Students**

**Mentoring of small groups**

Studies have indicated that interventions by preservice teachers in small group tutoring can impact significantly on elementary students’ reading levels (Hedrick, 1999). Mewborn found that small group tutoring in mathematics by preservice teachers can actually reveal information about elementary students’ learning that was previously unknown by their classroom teachers (1999). This is probably due to the individual attention given to students in the group over a sustained number of weeks. Students in Mewborn’s study made gains in mathematics achievement.

**Preservice Teacher Impact as Evidenced by the Oregon Work Sample**

Information concerning preservice teachers’ impact on student achievement aligns closely with a core belief held by many educators that teachers make a difference to student achievement (Wright, Horn, & Sanders, 1997). In fact, studies indicate that teachers are probably a major factor in determining student performance (Schalock, 1998). The question remains then as to what impact preservice teachers should be expected to have on student performance.

In Schalock’s study, preservice teachers required to design and teach a unit of work in Oregon have a significant impact on learning (1998). Pretest and posttest data, as well as ongoing assessment of various kinds, are used to measure student achievement. This study indicates that an expectation of student growth as the result of preservice teacher intervention is reasonable towards the end of their student teaching experience.

**Conceptual Framework: Performance Based Assessments**

Wilson indicates that preservice teacher assessment should have certain essential components (1995). In particular, evidence of active student engagement and resultant achievement must be part of an effective assessment process. Teacher licensure must demand that preservice
teachers demonstrate application of the knowledge learned in their university courses (Schalock, Schalock, Cowart & Myton, 1993). Many teacher education programs are moving to alternative assessment methods such as PBAs as a means to assess preservice teachers (Turner, 2002). PBAs allow the development of preservice teachers over a period of time (Baron and Wolf, 1996).

According to Snyder, Elliott, Bhavnagri, and Boyer, assessment should provide feedback to assist both the preservice teacher and the program as a whole (1993-94). The use of PBAs promises to give important feedback to universities about their teacher education programs. In addition to assessment information, PBAs can assist in the development of effective teachers by allowing preservice teachers to align theory with practical experience.

According to Johnson, using performances in assessment implies a particular structure (1996). He describes seven main parts to a performance:

<table>
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<th>Performance Characteristic</th>
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<tr>
<td>involves a complex goal and requires good judgment</td>
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<td>results in a “whole” that is more than the sum of the parts</td>
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<tr>
<td>is personalized by the student</td>
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<tr>
<td>does not involve “pat” responses and indicates mastery of criteria</td>
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<td>allows for refinement during the process, has known criteria, and gives many opportunities to demonstrate criteria</td>
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<tr>
<td>requires appropriate adjustments when errors occur</td>
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<td>results in student autonomy, where little assistance is required by completion</td>
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Methodology

The two research questions addressed in this study are as follows:

What effect did the lessons have on the elementary student achievement of the specific content selected for instruction by the preservice teachers?

What effect did the lessons have on elementary student attitudes towards mathematics?

Participants and Location

The preservice teachers who participated in this study were in their final internship in a partner school that they had worked in throughout their teacher education program. This particular PBA was only one part of their overall internship. The study was conducted at Mountain View School with five preservice teachers and 24 elementary students in grades two and five. The school is an alternative public urban school of choice available to students pre-kindergarten through twelfth grade from throughout the district. Parents, students, and teachers choose the school because of the emphasis on self-directed learning and active participation in the learning process in and out of the school setting. Students are organized in multi-aged groups based on interests, needs, and developmental levels. The students in this
study were selected from the Early Learning Center (ELC) groups of grades K-2, and the Intermediate Area (IA) groups of grades 3-5.

**Student Characteristics.**
Following the grading of pretests the clinical teachers, preservice teachers and the site coordinator discussed specific group composition. Various criteria such as common needs, behaviour, attitude, and personalities were considered when forming the groups.

While the students could not be characterized by a single description, there were some commonalities that helped to form a student profile. All of the students had experienced difficulties with mathematics in the past. In addition, one student was visually impaired and had an Individual Education Plan (IEP). The students seemed to have little confidence in their ability, and fragile self-images as mathematicians.

Patterns of difficulty had been observed in the students for some time. The pretest provided some useful specifics but basically confirmed what the clinical teacher was already aware of. Students’ difficulties with mathematics were perceived as significant and were believed to be preventing progress in the subject. Clinical teachers believed that the students’ attitude problems were closely connected to their confidence levels.

As well as the students generally disliking the discipline, they also viewed it very traditionally. Although vague connections to cooking and shopping were mentioned, mathematics was most frequently described as algorithms used to solve problems given by the teacher. Overall, the students did not feel any personal connections to mathematics.

**Structure**

During this study, preservice teachers took total responsibility for the mathematics instruction of between four and seven elementary students. The preservice teachers worked with their group of students on a daily basis for three months. In addition to mathematics, preservice teachers taught all subject areas to the whole class and this included a two-week solo block. The following lists details the PBA requirements for each of the preservice teachers:

- administer (Colorado School Assessment Program)CSAP-like tests to elementary students
- grade the tests with clinical teachers
- select students for the group with clinical teachers and the site coordinator
- interview students
- examine examples of students’ work
- write case studies of each student’s mathematical strengths and weaknesses
- determine individual and group goals
- design instruction for the group
- administer instruction
• conduct ongoing assessment of students’ achievement
• administer CSAP-like tests after three months of instruction
• grade tests
• reinterview each student
• write summaries of each student’s progress during the three months
• write a summary of the PBA experience

Interviews, on educational philosophy, pedagogical beliefs, and knowledge of student’s learning were conducted with each preservice teacher at the beginning and end of the study. Throughout the instructional period, preservice teachers conducted ongoing assessment of student progress. Preservice teachers met in focus groups with their peers to express any concerns, discuss group progress, and seek advice concerning instructional queries. Preservice teachers also kept daily journals concerning all aspects of their individual mathematics groups. The journals included lesson plans, work samples, ongoing student progress information, student problems, and preservice teacher reflections.

Data

Both quantitative data, in the form of pretests and posttests for the elementary students, and qualitative data, in the form of interviews, focus groups, journals, observations, and artifacts were collected during the study. Test data were analysed statistically and interpreted with the additional qualitative data concerning student achievement. Codes arose partly from the literature review and partly from emergent themes following an initial reading of all documents. Each document was then examined on the basis of the selected codes and coded accordingly.

Following this initial analysis, I used the model function to visually display the codes and their connections. This allowed me to see more clearly any relationships between the data. Documents were recoded as new codes emerged and were examined both vertically across all of the students and horizontally for individual students. Fontena and Frey, who advise researchers to interpret both individual instances and an aggregation of instances, espouse this method (1994). I conducted searches for relationships using groups of codes and participants. This led to some conclusions that can be generalized from the analysis.

In general, analysis was used to both filter and funnel data. Context and relevance determined the importance given to individual pieces of data. Each stage of analysis led to an aggregation of themes into main categories and ultimately allowed the research questions to be answered. To allow the reader to interpret the data, a quasi-statistical method was used to count the number of times particular themes were mentioned (Ratcliff, 2003).
Results

To assist the reader, a key is used to identify participants:
(a) TC signifies a teacher candidate
(b) S signifies a student

Affective Growth of Students

Where Did the Students’ Attitudes and Beliefs Begin?

At the commencement of the study, student attitudes varied from disinterest and animosity to enjoyment of mathematics. It is true, however, that the majority of the students expressed negative attitudes; in fact, 25 instances of negative mathematics attitudes were related by preservice teachers. The students gave an impression of feeling isolated when doing mathematics. “Something you do that’s really hard, by yourself, and you have to think really hard” said Katie (S) when expressing some of her frustrations. Many of the students described mathematics as uninteresting and irrelevant.

Data revealed a definite link between attitude and difficulty. For example, when asked whether they liked mathematics 18 students said “No because it is hard”. The areas most frequently described as difficult by the students were skip counting, word problems, time, multiplication, division, fractions, and worksheets. A few of the older students explained that mathematics was easier when they were younger.

There was a close relationship between understanding of specific concepts and attitude. Caleb’s (S) comments were summarized by Mary (TC) as follows: “It is boring. He does not like math because it is too hard. He used to enjoy it when he was little and it was easy”. Other students expressed affinity for concepts that they had experienced success with, such as multiplication, and disdain for concepts that they could not understand, such as long division. In all, 80% of the students had negative attitudes towards mathematics at the beginning of the study.

Five students described mathematics as boring; some as the least liked subject. A strong dislike is clearly expressed in the following: “Math is the worst part of my day”. Furthermore, four students indicated that their attitude towards mathematics was partly dependent on its relevance to their own lives.

When asked specifically what mathematics is, one second grade girl responded as follows: “Something you learn from, something you learn as a kid that makes you smarter”. Some of the older students indicated that mathematics is necessary to get a job in the future. While many of the students initially described mathematics in a school context, after further questioning by their TC, most acknowledged the link between mathematics and everyday life. The most common examples given of mathematics’ connection to the real world involved cooking and shopping.

ELC students experienced more difficulty in describing what mathematics is. Even with further probing about outside connections, some of the ELC students responded with school-based generalities. For example, one girl when asked “Do you use math in your life?” responded “Yes, when I’m sick my mom gives me math to do”.

It was true, however, that despite previous problems with mathematics, students perceived the groups optimistically. The following example illustrates one student’s attitude. Madeline (S) was excited to be chosen for the group. Bob (TC) believed that her enthusiasm related to her perception that the group would provide her with an opportunity to receive extra help and thus make significant progress. She looked forward to the math group meeting each day.
There were certainly many positive comments (20 cited) but many of these contained an element of negativity. For example, one student said that “the Math Blaster computer game is kinda fun. It’s timed, though, and if you don’t get done in time, it tells you that you have not achieved mastery”. While 35% of the students expressed positive attitudes towards mathematics at the commencement of the study, only 20% of the total students gave wholly positive responses. Fifteen percent of the 35% gave mixed responses to the attitude questions. In general, the students began with little confidence in their mathematics ability and an overall dislike of the subject.

**Learner Considerations.**

After examining available student data and speaking individually with the students, TCs summarized each student’s strengths and weaknesses. As a result, TCs formulated both content-oriented and affective goals for individuals and the group. Some of the goals were quite general. For example, one goal was “to increase the students’ confidence in their mathematical abilities”. Other goals were very specific for individual students. Jill (TC) wrote the following goals for one of her students: (a) to work on comprehending and organizing information in charts, (b) to work on the different steps of solving a problem such as what it is asking for, (c) how to go about solving the problem and (d) how to answer it sufficiently to work on number skills such as adding and subtracting fractions and multiplication.

**Affective Development.**

After a couple of weeks, it was clear that many of the students were showing more enthusiasm for mathematics. Evidence of eager participation characterized most of the groups. One TC reported that a parent had observed a significant attitude improvement in her daughter with regards to mathematics. In fact, the parent stated that her child talked constantly and excitedly about the mathematics group.

Mary (TC) wrote the following in her journal during the second week: “Throughout the week I have noticed that they keep each other on track (more so than if sitting with friends). They are also willing and eager to explain things to one another using manipulatives and pictures. I notice that they have all identified one another to have different strengths.”

After a few weeks, Bob (TC) recorded the following in reference to a student who had begun with a very low confidence level. “She was very excited about presenting our graph of numbers and hands to the rest of the class, and took it upon herself to lead the other three members through the sharing and to answer the questions that were asked.” This same student was very enthusiastic, continually asking when math group was on that day.

After they had reflected on it, some IA students recognized that an improvement in attitude could be attributed to their better understanding. One student stated “I like it more, as I am beginning to understand it”. Furthermore, a number of students alluded to the connections between fun, understanding, and positive attitude.

Over time, as TCs began to learn more specific information about students, individual needs were better met. For example, Susan (TC) determined that Rene (S) understood more when using manipulatives. In addition, Rene worked better in a small group (away from her friends).

Jackson (S) on the other hand, was perceived by his teacher as using only a portion of his potential and Mary (TC) attempted to use activities of interest to him. She further explained that Jackson (S) had “checked out” of school because he was to be home schooled the following year. Jill (TC) discovered that Eve (S) and Marie (S) worked best collaboratively as a pair, with hands-on activities, but became easily distracted with more friends.
In time, many of the initial management concerns disappeared. Giving consideration to students’ strengths and weaknesses, and catering to individual needs, produced a positive response in most students.

**What Were the Students’ Attitudes and Beliefs at the End?**

While there were many notable improvements in attitudes, the small group experience was not a panacea for change in all students. Given the many years of negativity, it would be unreasonable to expect a total reversal of attitudes in a few months. Complex factors worked together to impact attitudes and behaviour and it is impossible to separate them from one another. Despite an improvement in performance, some students remained unenthusiastic about mathematics activities.

Previous negative experiences seemed to impede the progress of a couple of students. Despite academic advancement, two students remained steadfast in their dislike for mathematics. One girl secretly did other work at any given opportunity. Another two students, who did become more positive during the study, allowed social issues to override academic concerns. It is not surprising that some students displayed inconsistent behaviour; sometimes engaging enthusiastically in activities and at other times causing disruption.

Another group of students expressed a renewed interest and confidence in doing mathematics but added that there were still a number of content areas that they disliked. One girl expressed her mixed feelings as follows: “I kind of like math. It makes my mind go crazy sometimes because it can be frustrating. Sometimes I get confused and frustrated. It is hard. When I learn more it will be more fun”. Likewise, one boy indicated that although he likes mathematics more now, it sometimes gets boring.

A strong majority of students (92%) displayed a definite improvement in attitude and confidence level. All of the younger students developed enthusiasm for mathematics during the course of the group experience. Bob (TC) wrote in his journal as follows: “By the end of our time, it was hard to contain their excitement. Do we have math group today? Some days I got to answer that question five or six times, interesting because there were only four kids in the group”.

Both Bob (TC) and Bethany (TC) indicated that improved confidence was the most notable change within their groups. Bethany’s (TC) students described mathematics as fun. One student, who had begun quite negatively, explained that mathematics was now her favourite subject. When interviewed, ELC students most commonly spoke about their enjoyment of time, games, cooking, and making things. Bob attributed part of the change to the trust and camaraderie developed in the group.

Positive attitude changes also characterized many of the older students in the study. According to interview and journal data, fifth grade students’ self-confidence and attitudes improved significantly throughout the course of the study. Towards the end of the study, TCs described students excitedly engaging in mathematics activities.

A number of IA students spoke favourably of the small group experience, ascribing much of their recent success to it. These students recognized the importance of understanding mathematics concepts before starting middle school. As much as they enjoyed their friends’ company, they also realized that they could be very distracting.
The Group Experience

Management Issues.
The students already knew each other from their multi-age classroom units. TCs had worked two days a week with the classes since September of the previous year. The small groups, however, were a new experience for all members. As with any group, individuals needed time to form a community.

While many of the students were excited to be part of the groups, the exact nature of the enterprise was still unknown. The first few weeks entailed a negotiation of relationships and a discovery of individual roles. Students and TCs structured their groups according to their needs and personalities.

Bob (TC) initially found his group members to have very short attention spans. He wrote that the four students had ten bathroom breaks during one session. Other TCs commented that students gave up easily when they perceived the problems as difficult. In addition, a number of the students exhibited behavioural problems. Some students distracted the group and prevented others from progressing. One student, Paul, refused to cooperate and was removed from Mary’s (TC) group after a few weeks.

TCs implemented a variety of management strategies in response to the behaviour problems. Immediate responses involved reminders concerning appropriate behaviour, movement of students, and assistance with work. These simple approaches were generally successful in controlling the groups.

In an effort to promote self-advocacy, TCs presented students with engaging activities that offered potentially high levels of success. While the TCs were cognizant of the content needs, they perceived the affective concerns as a higher priority. In fact, confidence and attitudes were mentioned without exception in the goals developed by TCs.

Within a short time, many of the behaviour problems lessened. Bob’s (TC) students were no longer requesting frequent bathroom breaks and Jill’s (TC) students began helping rather than distracting. In fact, most of the students began to anticipate eagerly their time in the groups.

After developing a better understanding of individual students, TCs were more able to use peer tutors. Susan (TC) describes her experience with one of the more capable students as follows:

“There have been several occasions on which Neva has stepped into the role of co-teacher and has aided other students in their learning by offering a different or more specific explanation of a concept. Sometimes we know a concept so well we forget some of the little steps and facts that it took to learn it and Neva is a student who can help in that area for both students and me as a teacher.”

One disturbing management issue centered on attendance. A few of the students exhibited chronic absenteeism and this impacted negatively on consistent learning in the groups. One ELC student visited relatives on a reservation in Arizona for weeks at a time periodically during the school year. Some of the older IA students demonstrated erratic attendance throughout the three months.

While it was outside of the TCs’ power to directly impact family choices, they were able to provide individual assistance to students missing work. This individual attention served to assist the students in understanding and achievement, and to promote more positive attitudes towards mathematics. Eventually, the students themselves expressed concern about their absences from the group.
Belonging

It was not surprising that students began to identify strongly with other group members over time. TCs described trust and understanding developing between group members. In fact, one TC explained that her students used each others’ strengths and weaknesses to form a supportive mathematical community. This particular group encouraged one student to be the problem interpreter, one an artist, one a scribe, and another a human calculator.

Many students recognized the advantages of working together in a small group. In an effort to further exploit their group support, some students chose to work together during other classroom activities. They explicitly attributed their “new successes” to the support of their peers and TC. For a number of students, rejoining the class became quite traumatic.

Back in the Class.

As the study effectively finished when the groups disbanded, limited data was gathered about classroom re-entry. During the final focus group and latter journal entries, TCs made some observations about students’ behavior in the larger classroom groups. In addition, clinical teachers remarked on students’ behavior within the main class groups.

One commonality centered on students’ participation in classroom activities. Prior to the study most of the students endeavored to be invisible, never volunteering answers. Following the group experience, numerous instances of student initiative in answering questions and in seeking visible roles were evident.

Students actually offered assistance to others in the class. Furthermore, their overall demeanor was significantly more positive. Many of the students showed a greater willingness to tackle difficult problems and to approach unknown situations.

Impact on Students

From Pretest to Posttest.

Positive changes in test scores were evident for all elementary students. Bethany’s (TC) group had the highest pretest scores but this is due in part to administration differences. The students in her group received help in reading the questions upon request. The mean pretest scores were 66% for the ELC students and 43% for the IA group.

As previously explained, this information allowed thoughtful group formation by the clinical teacher, TC and site coordinator. In conjunction with the students’ interviews and examination of previous work, TCs determined individual and group goals. While only part of the content deficits could be addressed during the study, all students showed significant improvement in test scores.

An examination of variance indicates that despite using specific selection criteria, the groups were quite heterogeneous. This does not pose a particular problem, as the intention was to study individual student progress. In fact, the change in test scores is the most important information. When the data was grouped together for all students, the mean increase in test scores was 28%.

The standard deviation of 16 was quite high, as increases actually varied from 7% up to 55%. This difference, however, does not diminish the results, as in all cases students displayed an increase in test scores. There are many possible explanations for this result. Given the small number of students (24) it is not unusual to have somewhat large variance in the data. In reality, the variance is basically an indication of the heterogeneity of the students. While the
students were purposefully chosen, the intention was to select students likely to benefit from the group, not to form homogenous groups of students with like abilities and needs. It is not surprising that the students began at different points, progressed individually and finished at different places as a result of the experience.

The real significance of the data is seen in the individual progress made by each of the students. Clearly, the group experience positively impacted each student’s mathematics test achievement. The data provides one part of the overall picture (see Table 1).

Table 1

*Total Test Scores, Variance and Standard Deviation*

<table>
<thead>
<tr>
<th>Test Categories</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>51</td>
<td>435</td>
<td>21</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>204</td>
<td>14</td>
</tr>
<tr>
<td>Change</td>
<td>28</td>
<td>247</td>
<td>16</td>
</tr>
</tbody>
</table>
Not only did the students improve their test scores, but they also broadened their range of problem-solving strategies. One example of this was given by Bethany (TC): “I noticed they used different strategies in the posttest than they used in the pretest”.

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Figure 1

*IA Test Scores*

![IA Test Comparison](image)

Figure 2

*ELC Test Scores*

![ELC Pre/Post Comparison](image)
Mathematical Understanding.

Evidence collected at the beginning of the study indicated that the students had formed definite misconceptions with regards to specific content. For example, many of the IA students did not really understand what a fraction was, viewing the numerator and denominator as separate numbers. As a result, the students were bound algorithmically by the fraction concept and unable to explore or use it beyond very simple set examples.

In many ways, students relied on procedures and had very little conceptual understanding of important content areas. Data indicated that ELC students did not understand place value and struggled with pattern formation beyond a rudimentary level. Lack of generalization of concepts had resulted in these students requiring significant and frequent individual instruction.

Low affective skills in mathematics also impacted students’ motivation to learn and persist. In general, these students gave up easily and were careless with their work. This was evidenced by the fact that many questions were left unanswered in the pretests.

Early observations depicted students with low expectations of success, coupled with coping strategies that enabled students to write down answers. This involved seeking help from peers, copying work and writing random numbers with no particular relationship to the question. Some of the older students had become quite adept with these strategies. For this reason, progress was initially slow for some of the students. It was almost impossible to improve conceptual understanding while they had little belief in their ability to do mathematics. TCs chose activities that gave students frequent small measures of success. In addition, students engaged in fun activities that related to their background experiences.

Academic Progress.

Students displayed improvement in content knowledge and conceptual understanding. ELC students made progress with place value, patterns, and time. While IA students gained knowledge in a number of different areas, most students developed a deeper understanding of fractions and decimals (particularly in new contexts). In addition, many of the students demonstrated better reading and problem-solving skills.

For example, Jill (TC) described marked improvements by most of her group. In particular, students developed good conceptual understanding of fractions and improved number sense. While two students were more successful with word problems, the others remained unsure of their abilities in this area. Students in Jill’s (TC) group gained geometry skills in both perimeter and area.

Mary’s (TC) group displayed a mixture of growth. All but one student gained a solid knowledge of fractions. Half of the group became comfortable with decimals, while the others struggled with the place value concept in decimals. Word problems continued to hamper two students but the remainder of the group gained confidence in this area.

Data Connections

Linking Affective Characteristics and Achievement

Progress was made towards most individual and group goals. Affectively, the vast majority of students expressed an increased confidence and interest in mathematics, shown in Table 2. Confirming evidence of this affective growth came from various sources. Students verbally described themselves as more capable in mathematics. Observations indicated a greater willingness to attempt new problems and to show persistence. In addition, teachers noted increased participation from the students after their return to the large class groups.
While some students had broadened their mathematics beliefs to include more real world connections, data did not provide definitive evidence. Examples of mathematics in everyday life, such as cooking, buildings, and money, were readily acknowledged by many of the students at the study conclusion. It was clear, however, that the primary view of mathematics remained school connected.

Table 2

Attribute Connections

<table>
<thead>
<tr>
<th>Attribute</th>
<th>PreStudy</th>
<th>PostStudy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaknesses</td>
<td>(47) 77%</td>
<td>(10) 29%</td>
</tr>
<tr>
<td>Strengths</td>
<td>(14) 23%</td>
<td>(24) 71%</td>
</tr>
<tr>
<td>Positive attitude</td>
<td>(20) 44%</td>
<td>(19) 79%</td>
</tr>
<tr>
<td>Negative attitude</td>
<td>(25) 56%</td>
<td>(5) 21%</td>
</tr>
<tr>
<td>Test scores</td>
<td>51%</td>
<td>79%</td>
</tr>
</tbody>
</table>

The ELC groups engaged in cooking and building a wooden box, but the IA groups concentrated on individual mathematics concepts through a hands-on approach. The students gained conceptual understanding but did not have much opportunity to make outside connections with the content. Immediate needs, such as CSAP and impending middle school, tended to dictate the instructional choices for the IA students. In addition, it is unreasonable to expect significant alteration in beliefs in just a few months.

Beliefs are deeply embedded and research emphasizes the difficulty in changing them (Chinn & Brewer, 1993). IA students, in particular, had viewpoints and values developed over a number of years in school and at home. The complexities of home and school influences are almost impossible to separate and make precise data analysis in this area difficult. In fact, even evidence that contradicts beliefs may be altered by an individual to fit into his/her current schema, rather than impacting perspective.

Definite links between attitudes, affective characteristics and mathematics understanding were clear throughout the study. Students’ confidence levels, commitment, interest, and academic progress were closely connected. Analysis revealed that the study factors form an intricate web of connections that simultaneously impact the others, illustrated in Figure 1. The factors of aptitude, attitude, beliefs, background experiences, school, and home are inextricably connected and largely determine student progress and confidence.

An analysis of student strengths and weaknesses revealed an increased awareness of strengths by individual students. Students began to openly acknowledge each other’s strengths and this further affirmation produced more self-confidence. It became clear that students were able to seek support from one another based on characteristics observed in group members. Evidence was seen in student conversations, group interactions, and interviews.
In addition, students’ understanding of their limitations allowed appropriate development of strategies to help overcome them. For example, a student who realized that she was easily distracted by particular students chose to isolate herself from these students. Recognition of individual weaknesses allowed TCs to purposefully individualize instruction.

**Small Group Impact**

While it is impossible to single out the influence of the small groups from other factors, there is no doubt that the role was significant. Previous research has indicated that small groups impact student achievement and attitude (Mewborn, 1999). Most of the students spoke very positively about their group and looked forward to being part of it. Some of the students specifically indicated that they believed that they learned better in small groups. One of the most important factors was the individual attention made possible by the small groups. Students’ specific needs were met almost daily. TC journals drew clear word pictures of activities chosen and altered to suit individual student requirements.
As the small group communities developed, students began to feel very comfortable seeking help. In general, they appeared to respect one another and supported each other’s struggle to learn. Peer assistance provided growth for the tutor and learner. Clearly the improved mathematics self-esteem, observed in many students, arose in part from the unique opportunities afforded through the groups. It was encouraging to observe evidence of this confidence outside of the small groups.

Mary (TC) commented that “the best things my students have learned, and other students are not necessarily as confident with this, is stopping themselves when they don’t understand something, because in the small group they couldn’t pretend they understood it, whereas in the whole class it is really easy to do that, hang out with smarter kids and have that friend help them but they don’t really have the understanding of it”.

Prospects for leadership, previously unattainable by these students, arose naturally within the groups. Bob (TC) described how Madeline (S), a visually impaired student, led the group through a presentation of data given to the whole class. Deborah (S), a shy IA student, chose to show the group her solutions to difficult problems and continued to participate when the group returned to the large class group.

Conclusions and Implications

Benefits for Schools
Given the increasing demands for accountability in schools, it is important that preservice teachers contribute positively to schools during field experience. The cost of field experience is significant in terms of finance, time, and effort. Field experience must be mutually beneficial for the universities and schools.

Results of this study clearly show that preservice teachers can positively impact the achievement and attitudes of elementary school students. A number of these students were at risk for continued low achievement in mathematics. Progress made during the three month study has the potential to improve students’ mathematics performance for years to come.

Multiplication of this individual effect will flow through to school test results. Schools unable to show improvement in test scores have been threatened with loss of funding and closure. Any program that contributes to improved test scores will be given full support in schools.

While it is imperative that field experience is first and foremost for the development of preservice teachers, benefits to schools and their students cannot be ignored. Preservice teachers have always contributed to schools but supportive data has rarely been collected to provide substantive evidence. It would be wise for teacher education programs to collect data more systematically concerning preservice teacher impact on schools during field experience.

Future Directions of Research
There are two main areas of research that lead directly from this study. First, a similar study in a different setting will provide important information concerning the generalizability of the results. Secondly, a study of the long term impact of the PBA on the elementary students could provide valuable information concerning small group participation. Are the students’ more positive attitudes maintained over the next few years of schooling? What is the long term impact on student achievement in mathematics?
References


