An investigation into traits that characterize high quality mathematics teachers and instruction

Ali S. Webb, Kelly D. Bradley, and Shannon O. Sampson

University of Kentucky
Abstract

According to the No Child Left Behind Act of 2001 and “The Facts About Math Achievement” (July, 2002), achievement in mathematics among America’s youth is imperative, yet children are not excelling in math at the same rate as in subjects such as reading. A study conducted by the National Assessment of Education Progress showed that while an achievement in math is slowly improving, “only a quarter of fourth- and eighth-graders are performing at or above proficient levels in math, and twelfth-grade math scores have not improved since 1996,” (NAEP, 2000). This review of literature reveals suggestions for multiple approaches to improving the quality of mathematics instruction and to better preparing pre-service mathematics teachers. This information will aid in the modification of curriculum and instruction and the development of teaching techniques to improve mathematics achievement among our nation’s children.
An investigation into traits that characterize high quality mathematics teachers and instruction

According to the No Child Left Behind (NCLB) Act of 2001, achievement in mathematics among America’s children is imperative, yet children are not excelling in math at the same rate as in subjects such as reading. Annually, the National Assessment of Educational Progress (NAEP) investigates the trends of achievement in all subject areas among children in grades four, eight, and twelve. A study conducted by NAEP in 2000 showed that while achievement in math is slowly improving, “only a quarter of fourth- and eighth-graders are performing at or above proficient levels in math and twelfth-grade math scores have not improved since 1996,” (NAEP, 2000). Beginning this year, it is required that the progress of students in mathematics be monitored on a yearly basis in the third- through eighth-grade levels.

The purpose of this study, based on the current pilot study, *Assessing quality—A macro versus micro approach to high school mathematics education* at the University of Kentucky, is to determine the extent to which the literature addresses the topic of high quality math education and how previous researchers have defined high quality mathematics teachers and curriculum. This knowledge can then be used to modify existing curriculum or aid in the development of techniques that teachers may implement in order to provide the best math education possible to all students. As stated by Fenstermacher and Richardson (2005), “Good teaching is teaching that comports with morally defensible and rationally sound principles of instructional practice. Successful teaching is teaching that yields the intended learning,” (pg.189). This review will examine the difference between good teaching and successful teaching as it is represented in and examined by the literature.
Multiple theories exist as to the root explanation of underachievement in math across the United States. The blame is placed on everything from the teacher and students to societal and familial situations beyond the students’ control. Holloway (2004) outlines one such example, in which minority students, African-American and Latin American children in particular, are showing more deficiencies in mathematics on statewide assessments than Caucasian children across all grade levels. She postulates that the home environments of these children are not supportive and also claims classroom environments are not ones in which expectations are equal for all students.

Connected to such findings, the National Council of Teachers of Mathematics (NCTM) developed a checklist of ways in which teachers can improve equity as well as the overall quality of instruction in their classrooms. Some recommendations include: high expectations for all students, coherent curriculum of important mathematical skills across grade levels, basing the teaching of new knowledge on prior knowledge, using assessments to provide both teachers and students with information about their progress, and implementing technology that enhances student’s learning (Holloway, 2004). These modifications, along with others, are beneficial as well as quite useful in increasing the mathematics achievement scores of children in all grade levels, not just the frequently assessed fourth-, eighth-, and twelfth graders.

Methods

In a review of the literature, various techniques and research methods are used to determine the level of quality of mathematics teachers and curriculums such as surveys, interviews, and observations of classrooms. These techniques and methods were outlined in articles found using the computer-based ERIC and EBSCOhost research databases, specifically
located using keywords such as “teacher quality,” “quality mathematics instruction,” as well as “teacher characteristics.” Articles published in peer-reviewed journals and other educational periodicals as of the year 2000 were included as part of the literature review. Exceptions include Heid (1997), Niess (1999), and Trigwell, Prosser, and Waterhouse (1999), which were utilized based on their relevance to the topic of high quality mathematics instruction and curriculum. Upon further review of the literature and completion of content analysis, the attached graphical matrix displays a summary of findings as related to high quality mathematics instructors (see Table 1).

Results

Information included in the No Child Left Behind Act of 2001 states that only “forty-one percent of eighth-grade mathematics teachers majored in math in college, thirty percentage points below the national average” (NCLB, 2001). It was because of statistics such as this that the NCLB Act and similar policies were developed; the goal being to ensure that every classroom in every state has a highly educated, prepared teacher by the conclusion of the upcoming 2005-2006 academic year. While NCLB requires highly educated, prepared teachers, the question still remains as to what makes a quality teacher. The review of the literature in this area reveals four overarching themes related to effective mathematics classrooms: teacher characteristics, use of technology in the classroom, type of curriculum and method of instruction, and teacher preparation.

Teacher Characteristics

The attitudes and behaviors of teachers, as well as the manner in which they interact with their students are shown to have important and lasting effects on the students they teach. According to Trigwell et al (1999),
when teachers report that they have the student the focus of their activities, where it matters more to them what the student is doing and learning than what the teacher is doing or covering…their students are less likely to be adopting a surface approach [to learning]” (p. 67).

Weiss and Pasley (2004) concur, stating, “high quality classrooms are both respectful and rigorous…[where] students feel free to contribute their ideas…and are also challenged to engage deeply with the content” (p. 26). They also add that teachers hold the responsibility for ensuring that this type of classroom climate is sustained throughout the entire school year. Additionally, Ginsburg and Golbeck (2004) claim, “mathematical thinking develops in a social and emotional context,” which is somewhat dependent upon the instructor’s attitude towards the subject matter (p.192). They continue by stating, “children can get excited or terrified about learning mathematics” (p. 192). Studies conducted by Beishuizen, Hof, van Putten, Bouwmeester, and Asscher (2001), Day (2000), and Bikmaz and Guler (2003) offer support to the aforementioned findings.

Application of Technology

With the advancement of technology and the creation of the information highway in today’s society, students’ accessibility to technology in the classroom has also become important. Mathematics classrooms, in particular, have been shown to greatly benefit from the services that computers, calculators, and other devices can provide. For some children, understanding mathematical processes can be difficult and can evoke feelings of anxiety and fear. One way in which teachers can alleviate these concerns is through the use of technology as an instructional tool.

Margaret Niess is an advocate for the integration of technology into mathematics classrooms. She claims technology “brings abstract concepts to life in a colorful, interactive, engaging way” (1999). According to Niess, students can utilize functions of computers such as
calculators, spreadsheets, and interactive diagrams to better understand the mathematical concepts they are attempting to master; adding, “[students] can do the problem again and again without embarrassment until they get it right” (1999). Computers can serve other purposes in the classroom beyond the lesson being taught at any given time.

Additional methods of technology such as virtual discussions can be used by both teachers and students to share new teaching methods and gather helpful information from others on topics with which students and/or teachers may be experiencing difficulties (Flecknoe, 2002). Furthermore, M. Kathleen Heid states four principles supporting the use of technology in the classroom: technology allows instruction to be more “student-centered,” enforces the importance of “being a mathematician,” provides instant feedback to the student, and shifts the responsibility of student learning from “teachers and the text” to the students themselves (1997).

However, while the acquired literature insists on the importance of utilizing technology in the classroom, none of the articles examined provides empirical evidence to support their claims or to indicate any correlation between technology use and improved academic performance on in-class examinations or standardized tests, for example. Rather, technology is viewed as an important part of classroom curriculum due to the ever-increasing prevalence and access to information in today’s society. The research shows instead a desire to parallel the classroom environment with that of the outside world.

**Focused Curriculum and Instruction**

Course content and manner of instruction are vital components in the quality of students’ acquisition of knowledge. In support of this, Driseen and Sleegers (2000) offer four features characterizing quality instruction: consistency, cohesion, constancy, and control. According to their research, in order to ensure that students are receiving “effective instruction,” teachers
should work together to develop similar teaching styles across classrooms and grade levels so that students will be adequately prepared to matriculate to the next grade level when the time arises. Achieving this is possible through the use of similar teaching aids, “curricular materials, and teaching behaviors,” (p.58). Studies conducted by Meijnen et al. (2003) support this claim, finding “when teachers used a mixed-type of method [of instruction], growth in math achievement was substantially lower than when a traditional or a modern method was used”.

Assigning homework has also been shown to have an effect on student achievement in mathematics. In a study reported by Jong, Westerhof, and Creemers (2000), based on 50 studies depicting the correlation between time spent on homework and student achievement, “43 studies indicated that students spending more time on homework had better achievement scores while only seven indicated the opposite,” (p. 133). Jong also states, in his particular studies, “the amount of homework was the only homework variable related to achievement,” including factors such as frequency of homework given and time spent on homework completion (p. 130).

Teacher Preparation

In a course as potentially difficult as mathematics can be for some students, being taught by an educator with expertise in the area of mathematics is essential, making the quality of teacher preparation crucial. Xin Ma (2003) states “students construct attitudes and anxieties about subject matters in the same ways that they form identities or come to understand other aspects of their world,” (p. 439). As previously mentioned, less than one-half of eighth-grade math teachers have a college degree in mathematics, and considerably less when compared to the averages of teachers in other subject areas (NCLB, 2001). Therefore, it is important that mathematics educators are confident in their knowledge of the material they are presenting to the students.
Professional development aids in the acquisition of teachers’ knowledge in their particular subject areas and is also beneficial in preparing quality mathematics educators, a process that many researchers consider continues throughout teachers’ careers. Teacher portfolios, used in some professional development workshops, provide experienced teachers with a wealth of information pertaining to the prospective teachers’ preparedness. Portfolios “serve as a forum for professional learning through collegial engagement…and can be used by experienced practitioners to assess as novice’s qualification for professional practice” (Hartmann, 2004, p. 392). According to Graham and Fennell (2001), “teachers need to have a profound understanding of fundamental mathematics,” and “as teachers gain experience in relating mathematics to pedagogy, they will be able…to provide engaging instructional opportunities that will meet” the needs of their students. Preparing and retaining high quality mathematics educators is essential in ensuring that our nation’s children receive the best education as possible.

Implications for Future Research/Educational Importance

Research in the area of what defines quality mathematics education sheds light on the problems pervading current mathematics classrooms and curriculum. Information extracted from the literature lays the foundation for further research in this area. It may also be beneficial to math teachers across all grade levels, as well as to school administrators and those teachers whose job it is to instruct future teachers. The review could be used to inform the development of new teaching techniques that stimulate more student involvement in mathematics, therefore increasing mathematics achievement on statewide and national assessments. Additionally, it could aid the development of new and improved curriculum that better addresses the needs of all students and could assist in the understanding of how to adequately involve students in the
Math Quality

As a result of the lack of empirical evidence on technology-based education, the review may also serve as a basis for future research concerning the effect that technology may or may not have on students’ academic performance and outcomes.

The review demonstrates the need for teachers who have a positive attitude about mathematics and who will challenge and involve their students throughout the learning process. Application of technology in the classroom results in more student-centered learning, and having focused curriculum and instruction allows for consistency of information delivery. Also, the more prepared America’s math teachers are, the more knowledge they have to share with America’s children and the better the opportunity for the child to learn quality information. In conclusion, high quality math education impacts children beyond the classroom. It prepares them for not only higher education at a college or university, but for the daily challenges life presents in adulthood, thereby making the subject of math education and its implementation vital to students, teachers, and academic institutions at large.
References


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<td></td>
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<td>Heid (1997)</td>
<td>Technology allows for student-centered instruction and increased group work; can aid in algebra, geometry, calculus, and statistics lessons</td>
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Table 1. Summary of Findings as Related to High Quality Mathematics Instruction