

Math Teacher Self-efficacy and Its Relationship to Teacher Effectiveness

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Mathematical knowledge and understanding is critical to a society for success in medicine, technology, finances, and many other fields. In order to foster and support successful mathematical leaders of the future, mathematics teachers must be effective (U.S. Department of Education, 2008). In 1999-2000 in the United States, 66.2% of middle school teachers and 24.6% of high school teachers did not have a certification or degree in mathematics. As a result 23% of middle school students and 10% of high school students were taught by teachers without proper content knowledge and certification training in mathematics (U.S. Department of Education, 2003). So, the need for effective mathematics teachers is great.

In recent years, educational researchers have closely studied teachers' self-efficacy beliefs and the impact of these beliefs on teacher effectiveness and student learning (Guskey & Passaro, 1994). Such researchers have framed their theories of this powerful variable around the self-efficacy component of social cognitive theory. As Hart, Smith, Smith, and Swars (2007) stated, "The relationship between teachers' beliefs and teaching is well-established. Beliefs influence teacher behavior and decision-making and change in beliefs is a crucial precursor to real change in teaching" (p. 239). Math teacher self-efficacy is an indicator of math teacher effectiveness and therefore a variable to strengthen and develop effective mathematics teachers.

What Is Self-Efficacy?

Self-efficacy is a motivational construct. Self-efficacy beliefs are people's judgments and perceptions of their own ability to perform an action (Pajares, 2002). The connections between self-efficacy and two theoretical perspectives: expectancy value theory and self-concept theory have been investigated (Pajares, 1996). Expectancy value theory can be summarized as, "Individuals will be motivated to engage in tasks when they value the outcome expected; they will be less

predisposed to perform tasks whose outcomes they do not value" (p. 558). Self-efficacy beliefs are related to such expected outcomes because beliefs contribute, in part, to outcomes (Pajares, 1996). For example, if a teacher is confident in his/her lesson planning skills, then the teacher will have high expectations for the success of the lesson. The converse is also true of those who lack such confidence. Pajares (1996) contrasts self-concept and self-efficacy by saying, "Self-concept differs from self-efficacy in that self-efficacy is a context-specific assessment of competence to perform a specific task...Self-concept is measured at a broader level of specificity" (p. 561).

Also important in understanding self-efficacy is the relationship between perceived self-efficacy and cognitive development and functioning. Within his research, Bandura (1993) described four major processes: cognitive, motivational, affective, and selection processes that influence perceived self-efficacy. Each of these four processes is central in understanding the power of self-efficacy beliefs. Self-efficacy is important because, "efficacy beliefs influence how people feel, think, motivate themselves, and behave" (Bandura, 1993, p.118).

Teacher Self-Efficacy

Teacher self-efficacy is identified as a type of self-efficacy that focuses on the views of teachers and their beliefs in their ability to teach and be effective in the classroom. Teacher self-efficacy can also be identified as a teachers' belief that he or she can make a difference in how well a student learns or the extent to which they can affect a student's achievement (Guskey & Passaro, 1994). Teacher self-efficacy has been related to "teachers' classroom behaviors, their openness to new ideas, and their attitudes towards teaching" (as cited by Tschannen-Moran, Hoy & Hoy, p. 215). Additionally, these researchers found that teacher self-efficacy influenced student performance, student attitudes towards learning and student

growth. Tschannen-Moran and Hoy (2001) stated, "Teacher efficacy has proved to be powerfully related to many meaningful educational outcomes such as teachers' persistence, enthusiasm, commitment and instructional behavior, as well as student outcomes such as achievement, motivation, and self-efficacy beliefs" (p. 783). With all of these crucial factors related to teacher self-efficacy, educational researchers have focused much effort to understanding teacher self-efficacy, its relationship to student learning and how it can be improved.

When discussing teacher self-efficacy, educators are often confused by the distinction between beliefs and knowledge (Pajares, 1992). Knowledge of the subject is different than a feeling about teaching it, yet often the knowledge that one has impacts this feeling about teaching. Pajares (1992) summarized the two when he stated, "Knowledge is the cognitive outcome of thought and belief the affective outcome" (p. 310). A 1989 study by Ernest, concluded that teachers may have similar knowledge but teach in different ways; therefore, their beliefs about teaching are more useful in understanding and predicting their effectiveness than their actual knowledge (Pajares, 1992).

Social cognitive theorists propose that behavior and environment interact to influence the beliefs of a person. Both student effects and school-level effects have been identified as environmental factors that can influence a teacher's self-efficacy. Student effects have been shown to include the type of students that make up a class and their abilities and behavior while school-level effects have been shown to include the climate of a school, the relationship that a teacher has with the principal, and the way in which decisions are made in the school. Depending on these external factors, researchers have found that teacher self-efficacy can be similar across an entire school and this collective efficacy can be very powerful in its effect on student achievement (Tschannen-Moran, Hoy & Hoy, 1998).

As Tschannen-Moran, Hoy & Hoy (1998) stated, "Teacher efficacy is the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a

specific teaching task in a particular context" (p. 233). The level of self-efficacy that a teacher has changes as he or she is faced with new challenges. For example, a new content or grade level may create uneasiness and impact a person's level of teacher self-efficacy. Teacher self-efficacy is very cyclical in nature which is one of the main reasons it is so important to educational research. Higher self-efficacy leads to greater effort, motivation and ability to instruct, which often leads to better student and teacher performance, which in turn leads to higher self-efficacy for the teacher. The reverse is also true. Lower self-efficacy leads to less persistence and motivation, which often leads to less effort and poor outcomes, which in turn leads to a lower sense of teacher self-efficacy (Tschannen-Moran, Hoy & Hoy, 1998). This cyclical pattern is consistent unless broken with new experiences, confidence, training or some other critical factor.

Self-Efficacy As It Relates To Effectiveness

Self-Efficacy and Performance in the Cognitive Domain

Many cognitive domains and performances have proven to be significantly related to perceived self-efficacies (Harrison, Rainer, Hochwarter, & Thompson, 1997; Artistico, Cervone, & Pezzuti, 2003). "Self-efficacy beliefs are strong determinants and predictors of the level of accomplishment that individuals finally attain" (Pajares, 1996, p. 545). For example, performance with computer-related tasks increased significantly with higher levels of self-efficacy and performance decreased significantly with lower self-efficacies (Harrison, Rainer, Hochwarter, & Thompson, 1997). These findings were confirmed in a second study with a contrasting cognitive task. This research found that perceived self-efficacy predicted results on problem solving tasks, even when comparing and considering young and older adults (Artistico, Cervone, & Pezzuti, 2003). It determined that participants with higher levels of self-efficacy outperformed other participants. Bandura (1993) supported such results by noting, "A person with the same knowledge and skills may perform poorly, adequately, or extraordinarily depending on fluctuations in self-efficacy thinking" (p. 119).

Self-Efficacy As It Relates To Teacher Effectiveness

Researchers have found that teacher self-efficacy can be directly correlated to a teacher's willingness to embrace new ideas and to their use of varying instructional strategies (Turner, Cruz & Papakonstantinou, 2004). Individuals with a high sense of teacher self-efficacy "are more likely to use inquiry and student-centered teaching strategies, while teachers with a low sense of self-efficacy are more likely to use teacher-directed strategies such as lecture and reading from the text" (Swars, 2005a, p.2). Teachers with low self-efficacy tend to lecture and use traditional methods while those with high self-efficacy will often group students together and allow students to explore and guide their own learning. This communication and group work is critical as students often learn best by communicating with one another and by being exposed to a variety of models (Turner, Cruz & Papakonstantinou, 2004). Additionally, teachers with a high sense of self-efficacy are more likely to try new strategies that may be risky or hard to implement.

In addition to instructional strategies, teachers with a higher sense of self-efficacy are less likely to be custodial and rigid in their approach with discipline (Rimm-Kaufman & Sawyer, 2004; Woolfolk & Hoy, 1990; Woolfolk, Rosoff & Hoy, 1990). These researchers found that teachers with a higher sense of self-efficacy were more capable with their ability to control classroom behavior as well as to influence decisions made by the administrators in the school. Both of these factors are essential to effectiveness in the classroom and school as a whole.

Although researchers have linked teachers' self-efficacy beliefs to their behavior in the classroom, the effort they invest in teaching their students, the goals in which they set for themselves and their students, and their persistence in making sure that learning occurs, little is known about the specific sources of teachers' self-efficacy beliefs (Tschannen-Moran & Hoy, 2007; Tschannen-Moran & Hoy, 2001). Bandura (1993) suggested that social cognitive theory provides the basic guidelines for such possible sources. Mastery

experiences, vicarious experiences, verbal persuasion and psychological arousal are proposed by Bandura "as the most potent sources" (Tschannen-Moran & Hoy, 2007, p. 944). Of these four, Bandura argued that mastery experiences are the most powerful. These mastery experiences come from actual teaching success with a teacher's sense of self-efficacy rising when they view their lesson a success and therefore gain expectations for success in the future. Vicarious experiences are often defined as the effects produced by the actions of someone else in which modeling occurs. Social persuasions are created when individuals develop self-efficacy beliefs based on the messages that they receive from others (Pajares, 2002). Psychological arousal is related to the feelings of happiness that a teacher experiences after an actual teaching accomplishment (Tschannen-Moran & Hoy, 2007). All four of these powerful influences impact a teacher's self-efficacy beliefs and their ability to reach the desired goal of being effective.

Teacher self-efficacy is a powerful construct that can influence student achievement as well as student motivation and student attitude towards learning (Rimm-Kaufman, 2004). A teacher's effort, goals and aspirations can all be affected by their level of self-efficacy. Their beliefs, attitudes and priorities are closely related to their classroom behavior and practices as well as improved student performance (Rimm-Kaufman, 2004). Pajares (1992) stated that "understanding the belief structures of teachers and teacher candidates is essential to improving their professional preparation and teaching practices" (p. 307). For all of these reasons, it is crucial that educational researchers further study the factors that influence teacher self-efficacy in order to determine what educators, colleges and others can do to help teachers gain a higher sense of teacher self-efficacy. Educational research in this field is not complete or as useful unless it provides insights into the relationship between teacher beliefs, teacher practices, teacher knowledge and student performance (Pajares, 1992).

Math Teacher Self-Efficacy as It Relates To Effectiveness

In the past three decades educational researchers have looked at the impact of teacher self-efficacy on teacher effectiveness, but few researchers have focused on the specific impact of math teacher self-efficacy. Teacher self-efficacy is often dependent upon the comfort level of the content, grade level of the students or specific topic being taught. For example, a teacher with high self-efficacy while teaching reading could simultaneously have low self-efficacy about teaching mathematics. Specific research regarding math teacher self-efficacy is needed in order to fully understand the connection between math teacher self-efficacy and student achievement in mathematics.

Teacher beliefs and their attitude toward mathematics play a key role in their effectiveness in teaching mathematics and their view of the definition of quality instructional practices. Knowledge as well as attitudes and beliefs have a direct influence on instructional practice (Wilkins, 2008). Studies have revealed that teachers with negative attitudes towards mathematics use more traditional teacher-directed instructional methods (Karp as discussed in Wilkins, 2008; Swars, 2005a). These teachers with a lowered sense of self-efficacy are more likely to refrain from using innovative or exploratory instructional practices. In contrast, teachers who like mathematics, feel confident with it, and feel effective in teaching it are more willing to be creative and use inquiry-based methods of teaching mathematical concepts (Wilkins, 2008).

A substantial amount of research with regards to mathematics instruction pointed to manipulative use as a crucial part of quality instruction. Educators believe that using manipulatives to explore and visualize concepts is a key factor in understanding mathematics content and not just process (Swars, 2005a; Swars, 2005b; Hart, Smith, Smith, & Swars, 2007). Teachers with high self-efficacy often use manipulatives as part of the teaching process while teachers with a lower sense of self-efficacy are often hesitant to use manipulatives while explaining concepts (Swars, 2005b). The importance of comfort and belief in

using materials associated with mathematics is highlighted as one way in which math teacher self-efficacy is important to mathematics teaching and learning.

Teachers' past mathematical experiences often influence their level of self-efficacy. In one study of math teaching effectiveness among pre-service elementary teachers with varying levels of mathematics teacher self-efficacy, it was discovered that teachers with a high sense of self-efficacy were more effective mathematics teachers than those teachers with a low sense of self-efficacy (Swars, 2005b). In this study, past experiences with mathematics were directly related to the teachers' math teaching self-efficacy. The teachers' self-efficacy level also had a direct impact on their willingness to embrace new instructional strategies and which classroom strategies that they chose to use (Swars, 2005b).

At the elementary level, researchers have begun to also look at the impact of math anxiety on math teacher self-efficacy. Math anxiety is often defined as being a severe discomfort or uneasiness that occurs when a person is asked to perform mathematically or required to manipulate numbers. Teachers with a high level of math anxiety often possess a low level of teacher self-efficacy. They sometimes avoid teaching mathematics altogether and pass their fear of the subject onto their students. Their effectiveness in teaching mathematics is directly impacted by this math anxiety and low sense of math teacher self-efficacy (Swars, 2005a). Among pre-service teachers, those with a low level of math anxiety had strong beliefs in their ability to be an effective math teacher, while those with a high level of math anxiety had less confident views of their ability to teach math effectively (Swars, 2005a).

In order to overcome a lack of confidence in teaching mathematics and raise a teacher's level of self-efficacy, many educators have looked towards professional development programs. Turner, Cruz, and Papakonstantinou (2004) stated, "Professional development programs are widely recognized as being successful in their ability to augment teachers' feeling of confidence for teaching mathematics" (p. 1). This study looked at a

particular professional development program for math teachers where the teachers were presented with a number of best practices, exposed to other teachers, and presented with the opportunity to participate in activities and watch others (Turner, Cruz & Papakonstantinou, 2004). It found that the teachers who attended this program left with a much higher sense of self-efficacy. Based on research such as this, educators are looking closely at available professional development programs and resources in order to provide teachers with a better opportunity to increase their level of math teacher self-efficacy.

Conclusion

Teacher self-efficacy is a powerful indicator of teacher effectiveness and effective mathematics teachers are critical to the success of the nation's future. It is important that math teachers be effective in the classroom in order to improve student achievement. The National Council of Teachers of Mathematics (2000) has presented a new vision for teaching mathematics and in this reformed vision, teachers are the most critical component. Teacher implementation of effective instructional practices are impacted by their level of math teacher self-efficacy and therefore, the importance of this construct is evident to the success of teachers and students.

Using the theories brought about in cognitive psychology and with social cognitive theory, self-efficacy as it relates to teacher self-efficacy has been placed at the forefront of educational research. The Rand Corporation conducted one of the earliest studies in which they found that teacher self-efficacy was the most important and powerful variable in predicting program success (Guskey & Passaro, 1994). Similarly, a 1979 study by Brookover and Lezotte found that "those in more effective schools had a stronger sense of efficacy and tended to feel more responsible for the learning of their students than did those in less effective schools" (Guskey & Passaro, p. 628). Because teacher effectiveness "is the major determinant of student academic progress" (Stronge, 2010, p. 1), researchers have since focused much of their attention on the impact of teacher self-efficacy on teacher effectiveness.

But, more research on teacher self-efficacy as it relates to teacher effectiveness should occur. Educators and educational researchers should continue to spend both time and resources in order to continue to research ways to improve teacher self-efficacy. This improvement in teacher self-efficacy can have a direct impact on teacher effectiveness in mathematics teaching and as Wright, Horn and Sanders (1997) summarized "differences in teacher effectiveness were found to be the dominant factor affecting student academic gain" (p. 66). Also, correlational research on self-efficacy and effectiveness would advance this topic. Teachers truly do make a significant difference for children and thus teacher self-efficacy is an important construct in the field of education.

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