IS A MATHEMATICS TEACHER'S EFFICACY INFLUENTIAL TO THEIR STUDENTS' MATHEMATICS SELF-EFFICACY AND MATHEMATICAL ACHIEVEMENT?

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The main purpose of this study was to examine the effects of fifth-grade mathematics teachers' efficacy (MTE) on their students' mathematics self-efficacy (SMSE) and mathematical achievement (SMA) in the classroom. Two instruments (for MTE and SMSE) were administered to 62 classes (62 teachers and 1283 fifth-graders) for gathering data, associated with SMA scores in school. Corresponding statistical analyses were applied to the obtained data. The findings revealed that mathematics teachers' efficacy beliefs were significantly influential to both SMSE and SMA. It also showed that MTE ratings could effectively predict SMA. Consequently, suggestions derived from findings and discussions were proposed for further improvement of these mathematics teachers' efficacy and, in turn, for enhancing fifth-graders' mathematics self-efficacy and mathematical achievement in the future.

INTRODUCTION

Contemporary educational reforms in many countries focus on advancing the quality of teaching and learning in every classroom (Goddard, Goddard, & Tschannen-Moran, 2007, Moolenaar, Sleegers, & Daly, 2012). Grounded on Bandura's (1977) social cognitive theory and his construct of self-efficacy (SE), teacher efficacy (TE) has been recognized as "a variable accounting for individual differences in teaching effectiveness" (Gibson & Dembo, 1984, p. 569) and has a strong relationship with student learning and achievement (Cantrell, Young, & Moore, 2003; Gibson & Dembo, 1984; Ross, 1998). Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) defined TE as "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. 223). Actually, from research in 1970s (e.g. Armor et al, 1976), "teacher efficacy was first conceptualized as teachers' general capacity to influence student performance" (Allinder, 1995, p. 247). Further, Ross (1998) indicated that most researchers treated "teacher efficacy as a type of self-efficacy" (p. 50). Since then, TE has been viewed as "self-efficacy beliefs directed toward a teaching context" (Knoblauch & Woolfolk Hoy, 2008, p. 167). That is, teacher efficacy referred to "their belief in their capability to have a positive effect in student learning" (Ashton, 1985, p. 142).

The concept of self-efficacy consists of two kinds of expectation, efficacy expectation and outcome expectancy. A teacher's efficacy expectation influences her/his thoughts and feelings, her/his selection of instructional activities, the amount of effort s/he

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spends in teaching, and the degree of her/his persistence while confronting difficulties (Bandura, 1981). The outcome expectancy refers to her/his own estimate of the likely consequences of teaching performance at the expected level of competence (Bandura, 1981). Applying this construct to the subject of mathematics, "Mathematics Teaching Efficacy Beliefs Instrument (MTEBI)" was originated by Enochs, Smith, and Huinker (2000) in measuring pre-service teachers' efficacy beliefs. Later, the researcher (Chang & Wu, 2004; Chang & Wu, 2009) adapted the MTEBI to assess elementary in-service mathematics teachers in Taiwan; that is, "Elementary Mathematics Teacher Efficacy Instrument (EMTEI)" was established consequently. EMTEI includes two cognitive dimensions: personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE). Accordingly, EMTEI is employed in this study to obtain targeted mathematics teachers' efficacy ratings.

As Bandura (1997) argued, SE, defined as "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3), had a great influence on one's task choices, effort, persistence, and achievement. Based on this concept, a student's self-efficacy refers to "belief in her/his capabilities to organize and execute the courses of learning". Thus, students who are self-efficacious in learning are likely to pay more efforts, persist longer while facing obstacles, and eventually attain better achievement. As to the domain of mathematics, students' mathematics self-efficacy (SMSE) beliefs have a powerful impact on the level of academic achievement and performance they may eventually achieve in learning mathematics (Chang, 2012; Kitsantas, Cheema, & Ware, 2011; Pajares & Miller, 1994; Pajares & Kranzler, 1995); that is, SMSE has been evidenced to predict students' mathematical achievement (SMA). In this study, "Elementary Students Mathematics Self-Efficacy Instrument (ESMSEI) is employed to assess targeted students' mathematics self-efficacy ratings, which was developed and validated by the researchers (Chang, 2012) based on Bandura's (1977, 2006) theory and his guidelines. ESMSEI also consists two cognitive constructs, "General Self-Efficacy—Related Mathematics (GSE-M)" and "Self-Efficacy for Mathematical Learning (SEML)".

Since teacher efficacy has a strong impact on student learning and achievement, does teacher efficacy beliefs have a direct influence on the development of students' self-efficacy in the classroom? In fact, several studies, domestically and internationally, indicated that a teacher's efficacy belief and her/his students' self-efficacy were significantly correlated (Bandura, 1982; Janet et al., 1995; Shao, 2005; Liu & Zhou, 2007; Tang & He, 2006). However, little knowledge was attained for the domain of mathematics learning, as well as for elementary students. Further, empirical evidences revealed that self-efficacy began to decline in grade 7 or earlier (Urdan & Midegley, 2003), particularly obvious in mathematics at the transition to middle school (Jacobs, et al., 2002). Thus, for fifth and sixth grades, children are positioned right at the developmental transition period, in which they confront with dramatically psychological, physiological, and social changes. As new challenges await them in this fast-growing stage (Schunk & Meece, 2006), to understand the

relationship between teacher efficacy and students' self-efficacy becomes more beneficial while learning mathematics. Consequently, the first intention of this study is to assess the effect of a mathematics teacher's MTE on her/his students' SMSE, who are at the beginning stage of this transitional period (i.e. fifth-graders).

As verified by the researchers' previous study (Chang, 2012), a student's mathematics self-efficacy (SMSE) is predictive to her/his mathematics achievement (SMA). In addition, teacher efficacy is significantly influential to students' learning. However, less empirical evidence existed in supporting the effect of teacher efficacy on students' achievement, especially for mathematics in Taiwan. Therefore, besides assessing the effects of MTE on SMSE, it is also essential to testifying the effects of MTE on students' mathematics achievement (SMA). Altogether, in this study, it is valuable to verify whether the two factors, i.e. MTE and SMSE, are predictive to SMA or not. This effort will help us to clarify the relationship among the three factors, which will be also useful for further improvement for the quality of teaching and learning in mathematics.

Based on the background and motivation stated above, the three purposes of this study are as follows: (a) to investigate the effects of teachers' MTE on their students' SMSE; (b) to examine the effects of teachers' MTE on their students' SMA; and (c) to assess the effects of MTE and SMSE on SMA. Based on foregoing purposes, this study has three research hypotheses as follows:

- H1: MTE has a significant effect on SMSE, and significantly predicts SMSE.
- H2: MTE has a significant effect on SMA, and significantly predicts SMA.
- H3: MTE and SMSE significantly predict SMA.

METHOD

A total of 62 fifth-grade classes, including a classroom teacher (who taught mathematics) and fifth-graders in every targeted classroom, were selected by a stratified random sampling method (by school size) in elementary schools in Taiwan. Thus, a total of 62 mathematics teachers and 1283 students participated in this study. Based on the purposes of this study, data were collected through background sheets (for teachers and students), MTEBI (for teachers), and students' MSEI and mathematics achievement in school.

"Elementary Mathematics Teacher Efficacy Instrument", adapted from Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) for pre-service teachers (Enochs, Smith, & Huinker, 2000), were used in this study in order to explore mathematics teachers' efficacy beliefs (Chang & Wu, 2004; Chang & Wu, 2009). The EMTEI consists of "Personal Mathematics Teaching Efficacy (PMTE, 13 items)" and "Mathematics Teaching Outcome Expectancy (MTOE, 8 items)", rated on a 5-point Likert scale; also, 5 items were written in a positive orientation and 16 items were written negatively. EMTEI has respectable internal consistency of .77, .81, and .71 for

the whole scale, PMTE, and MTOE subscales respectively; PMTE and MTOE accounted for 20.82% and 15.86% of variance, respectively. (Chang & Wu, 2004).

In measuring SMSE, Mathematics Self-Efficacy Instrument (MSEI) was developed on the basis of Bandura's (1977, 2006) theory and his guidelines, which includes "General Self-Efficacy—Related Mathematics (GSE-M, 24 items)" and "Self-Efficacy for Mathematical Learning (SEML, 23 items)", rated on a 100-point scale. MSEI has high internal consistency of .96, .93, and .95 for the total scale, GSE-M, and SEML subscales respectively (Chang, 2012). Also, GSE-M and SEML accounted for 27.68% and 20.41% of variance, respectively. Both subscales significantly correlated, $r = .74$, $p < .001$. Also, mathematical achievement in school was represented in terms of their overall mathematics scores at the fifth-grade level. Mathematics scores, named as mathematical achievement T scores (MA-T), were collected at the end of the school year and then transformed into T scores for further analyses.

RESULTS

For teachers, the mean rating of all 62 fifth-grade mathematics teachers on MTE was 78.95 (SD=7.01), which meant that on average they had nearly 75% confidence in their own mathematics teaching capabilities. Also, for students, the mean rating of all 1283 fifth-graders on SMSE was 70.19 (SD=7.25), which meant that on average they had nearly 70% confidence in their own mathematics learning abilities.

The effects of fifth-grade teachers' MTE on SMSE

In order to examine the effects of MTE on SMSE through ANOVA, all teachers' MTE ratings were divided into three levels, i.e. "high (top 27% of them)", "middle", and "low (bottom 27% of them) MTE. Further, regarding the effect of MTE on SMSE, the results showed that there were statistically significant differences in fifth-graders' SMSE ratings among the three levels of MTE, $F(2, 59) = 5.13$, $p < .01$. The strength of the relationship between MTE and SMSE, as assessed by η^2, was strong, accounting for 14.8% of the variance for MTE. The post hoc comparison based on Scheffé concluded that fifth-graders taught/led by the teacher with high MTE (M=73.95) scored significantly superior in SMSE than did those taught/led by the teacher with low MTE (M=66.93), while the other two comparisons were not significant (i.e. high MTE and middle MTE [M=69.80], and middle MTE and low MTE). In addition, fifth-graders taught/led by the teacher with medium MTE scored higher in SMSE than did those taught/led by the teacher with low MTE.

To determine whether a mathematics teacher's efficacy belief could predict her/his students' mathematics self-efficacy, a simple regression analysis of MTE regressing on SMSE was conducted. The findings showed that MTE significantly predicted SMSE, $F(1, 60) = 17.88$, $p < .001$, suggesting that 21.7% of SMSE variance was explained by MTE. The standardized regression coefficients indicated that MTE (B = .48, $t = 4.23$, $p < .001$) had significant effects on SMSE. In brief, these findings

indicated that fifth-graders who taught/led by the teacher with higher MTE would influence their students' SMSE. It means that a fifth-grade mathematics teacher with high MTE would be valuable in helping fifth-graders to build up their SMSE in the classroom. Accordingly, H1 was supported in this study.

The effects of fifth-grade teachers' MTE on SMA

Regarding the effect of MTE on SMA, the results showed that there were statistically significant differences in fifth-graders' SMSE ratings among the three levels of MTE, $F(2, 59) = 53.44$, $p < .001$. The strength of the relationship between MTE and SMA, as assessed by η^2, was quite strong, accounting for 64.4% of the variance for MTE. The post hoc comparison based on Scheffé concluded that fifth-graders taught/led by the teacher with high MTE (M=86.84) scored significantly superior in SMA than did those taught/led by the teacher with medium (M=81.46) and low MTE (M=71.42). In addition, fifth-graders taught/led by the teacher with medium MTE scored higher in SMA than did those taught/led by the teacher with low MTE.

To determine whether a mathematics teacher's efficacy belief could predict her/his students' mathematics achievement, a simple regression analysis of MTE regressing on SMA was also conducted. The findings showed that MTE significantly predicted SMA, $F(1, 60) = 119.02$, $p < .001$, suggesting that 65.9% of SMA variance was explained by MTE. The standardized regression coefficients indicated that MTE ($B = .82$, $t = 10.91$, $p < .001$) had significant effects on SMA. In short, these findings indicated that fifth-graders who taught/led by the teacher with higher MTE would influence their students' SMA. It indicates that a fifth-grade mathematics teacher with high MTE would be valuable in helping fifth-graders to increase their SMA in the classroom. Accordingly, H2 was supported in this study.

The effects of MTE and SMSE on SMA

To determine whether a mathematics teacher's efficacy belief and a student's mathematics self-efficacy could, together, predict a student's mathematics achievement, a simultaneous regression analysis of MTE and SMSE regressing on SMA was conducted. The findings showed that MTE and SMSE significantly predicted SMA, $F(2, 59) = 63.48$, $p < .001$, suggesting that 67.2% of SMA variance was explained by both MTE and SMSE. The standardized regression coefficients indicated that MTE ($B = .74$, $t = 4.23$, $p < .001$) yielded significant effects on SMA, which were greater than non-significant effects of SMSE ($B = .15$, $t = 1.83$, $p > .05$) on SMA. In summary, this finding revealed that fifth-graders who taught by a mathematics teacher with high MTE tended to have better mathematics achievement, with a minor support of her/his own and higher mathematics self-efficacy. Therefore, H3 was patricianly supported in this study.

DISCUSSION

MTE significantly influence fifth-graders' SMSE and SMA

First of all, the findings of regression analyses, paralleling with the result of ANOVA, indicated that MTE significantly predicted fifth-graders' mathematical achievement with 65.9% variance. This finding of significant effects of a mathematics teacher's efficacy belief on her/his students' mathematical achievement in school is corresponding to the previous studies (Ashton & Webb, 1986; Rosenholtz, 1989); even analogous to studies with different subject areas (Bandura, 1982; Denham & Michael, 1981; Janet et al., 1995). It is notable that MTE had great effects on students' mathematical self-efficacy as well. Thus, this result apparently indicate that the more efficacious a mathematics teacher the better her/his students' mathematical achievement in school. As mentioned previously, as teacher efficacy plays an important role on promoting students' learning achievement and their self-efficacy development in the classroom, we as teacher educators must devote extensive efforts to establish a positive and collaborative working and in-service learning environment that promotes mathematics teacher efficacy. In addition, all 62 mathematics teachers, on average, had nearly 75% confidence in their own mathematics teaching capabilities, and around 22 of them were even lower than 70%. This low efficacy and inadequate readiness in teaching elementary mathematics needs to be carefully acknowledged while discussing the future task of teacher professional development. Since teachers with high efficacy tend to put more efforts in preparing and teaching, persist longer while facing students' learning problems, and have more flexible selection of instructional activities, these enthusiastic actions combing with positive thoughts and adaptive expectations will be definitely beneficial for establishing a preferable learning environment, which in turn support students' mathematical learning.

Fifth-graders' SMSE had a effect on their mathematical achievement

In this study, all 1283 fifth-graders had averagely 70% confidence in their own mathematics learning abilities. Since "self-efficacy" was a powerful factor for students' learning performance (Bandura, 1977), which was evident in the researchers' previous study that the higher SMSE the better mathematical achievement (Chang, 2012), "how to increase or maintain the status of their SMSE became more essential to help them be successful in learning mathematics in school both at this transitional period and in the future" (Chang, 2012, p. 524). As a result, effectively providing a positive learning environment in this fast-growing and transitional stage will help to prevent possible declines of their SMSE (Jacobs et al., 2002), which is also helpful for promoting their learning achievement.

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