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Putting children and families first to ensure high academic achievement for all

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Focus on Mathematics Self-Efficacy

AT A GLANCE

Students success in mathematics is highly important especially in the current period when there are approximately 2.4 million vacant science, technology, engineering and mathematics (STEM) jobs in the nation to be filled (National Science Foundation, 2015). Students success in mathematics is found to be supported by their mathematics self-efficacy, which relates to the beliefs regarding the ability to perform various math-related tasks and behaviors. Self-efficacy has been defined by many and refers to an individual's judgment about being able to perform an activity. It is an individual's "I can" or "I can't" belief. This, in its turn relates to students' career choices. In order to be successful in todays world and to be marketable in STEM careers that are among those with much higher compensation. The purpose of this brief is to look at the research conducted on mathematics self-efficacy to get insight on what is being discussed in the research field. It is hoped that this information will have instrumental value for educators.

Introduction

What is Mathematics Self-Efficacy?

According to Bandura (1986), humans are capable of self-reflecting through which they evaluate and alter their own thinking and behavior. Self-evaluation includes perceptions of self-efficacy, that is, "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1997, p. 2). The beliefs of personal competence affect behavior in several ways. They influence the choices individuals make and the courses of action they pursue. Individuals engage in tasks in which they feel competent and confident and avoid those in which they do not. Self-beliefs influence individuals' choices and are instrumental in defining one's experience and providing an avenue through which individuals exercise control over the events that affect their lives. Efficacy beliefs help determine how much effort people will expend on an activity, how long they will persevere when confronting obstacles, and how resilient they will prove in the face of adverse situations—the higher the sense of efficacy, the

greater the effort, persistence, and resilience. In a similar manner, mathematics self-efficacy controls students' decisions to invest additional effort into learning mathematics and to pursue or not to pursue mathematics related careers, the amount of effort that they might invest in overcoming challenges. Students with low mathematics self-efficacy may believe that math-related things are tougher than they really are, a belief that fosters stress, depression, and a narrow vision of how best to solve a problem. High self-efficacy, on the other hand, can help create feelings of serenity in approaching difficult math-related tasks and activities as it does in other areas (Pajares, 1996). In other words, mathematics self-efficacy beliefs can be strong determinants and predictors of the level of mathematic accomplishments that students may finally attain.

The Role of Mathematics Self-Efficacy

Several empirical studies have been conducted on mathematics self-efficacy, identifying variables that may relate to it, and what its role may be for students' learning outcomes and future career decisions.

Skaalvik, Federici and Klassen (2015) conducted a study to analyze if teachers support and student self-efficacy mediated the relations between students' grades in mathematics and different measures of mathematics motivation. Participants in the study were 823 Norwegian middle school students. Indicators of motivation were intrinsic motivation, effort, persistence, and help-seeking behavior. The results of the study suggested that the relationship between students' grades and motivation were partly mediated through emotional support and self-efficacy.

Rahmi, Nadia, Hasibah, and Hidayat (2017) conducted a study to analyze the relationship between 7th grade students' mathematics self-efficacy and their mathematical communication skills. The result of the study suggested that students' self-efficacy influences students' mathematics communication skills.

Cleary and Kitsantas (2017) conducted a study to examine the relationships among background variables (socioeconomic status, prior mathematics achievement), motivation variables (self-efficacy, task interest, school connectedness), self-regulated learning (SRL) behaviors, and performance in middle school mathematics courses. Of interest was examining the mediation roles of both self-efficacy and SRL behaviors. Data about three types of motivation beliefs (self-efficacy, task interest, connectedness) were obtained from 331 middle school students using self-report questionnaires, while information regarding student SRL behaviors was obtained from teacher ratings. A model consisting from the variables above was designed and tested. The results of the study suggested that the overall model explained 51% of the variance in mathematics performance, a key finding was that both cognitive (i.e., self-efficacy) and behavioral (i.e., SRL) factors served as key mediators in the model, with each of these factors exhibiting unique effects on mathematics performance after controlling for prior achievement. Furthermore, each of the three motivation beliefs played an important role in the model, particularly regarding the explanation of SRL behaviors.

Tellhed, Bäckström, and Björklund (2017) tested self-efficacy (competence beliefs) and social belongingness expectations (fitting in socially) as mediators of gender differences in interest in STEM and Healthcare, Elementary Education, and the Domestic (HEED) spheres majors in a representative sample of 1327 Swedish high school students. Gender differences in interest in STEM majors strongly related to women's lower self-efficacy for STEM careers and, to a lesser degree, to women's lower social belongingness expectations with students in STEM majors. Social belongingness expectations also partly explained men's lower interest in HEED majors, but self-efficacy was not an important mediator of gender differences in interest in HEED. The researchers concluded that interventions designed to lessen gender segregation in the labor market need to focus more on enhancing females' self-efficacy in STEM and on the social

belongingness of students in the gender minority. Additionally, the conclusion was that to specifically increase women's interest in STEM majors, it is needed to counteract gender stereotypical competence beliefs and assure women that they have what it takes to handle STEM careers.

Mathematics Self-Efficacy and Career Choice

Sahin, Ekmekci and Waxman (2017) conducted a study to examine college students' science, technology, engineering, and mathematics (STEM) choices as they related to high school experiences, parent, teacher, and self-expectations, and mathematics and science efficacy. Participants were 2,246 graduates of a STEM-focused Harmony Public Schools (HPS) in Texas. Descriptive analyses indicated that the overall percentage of HPS graduates who chose a STEM major in college was greater than that in Texas state and national averages. The results of the study suggested that males and Asian students were more likely to choose a STEM major in college than females and non-Asian students. Moreover, students whose parents had a college degree in the U.S. are more likely to major in STEM fields than those who did not. Furthermore, males with higher mathematics efficacy and females with higher science efficacy were more likely to choose a STEM major than their counterparts with lower mathematics and science efficacy.

Yıldız and Özdemir (2019) conducted a case study to examine the relationship between mathematics self-efficacy beliefs and sources of self-efficacy in two elementary school students whose mathematics achievement are at different levels. The participants in the study were two 4th grade elementary school students: one with high mathematics achievement and the other with low mathematics achievement. The results of the study suggested that students' mathematics achievement was parallel to their mathematics self-efficacy beliefs. It was found that the student, whose mathematics achievement was high had higher mathematics self-efficacy than the students whose mathematics achievement was low.

Damrongpanit (2019) conducted a study to examine the influences of new teaching methodology on mathematics achievement towards mathematics attitude, achievement motivation, and self-efficacy of students as mediating variables. The study was conducted with 117 teachers and 2,205 students. The results of the study suggested that the attitude towards mathematics was the most important factor in explaining the academic achievement of individual students and that attitude towards mathematics related to achievement motivation and perceived self-efficacy of students by 60.50%. Additionally, the study suggested that the modern teaching method had positive effect on achievement both directly and indirectly which brings to attention the importance of learning-conducive instructional design.

Haciomeroglu (2019) conducted a study to examine the structure of achievement emotions (enjoyment, anxiety, boredom) and sources of self-efficacy (mastery experience, vicarious experience, social persuasions, and physiological state) of the elementary students by asking whether the two systems were related. Results revealed that the students enjoyed doing mathematics and felt less anxious and bored in different academic settings. Elementary students' sources of self-efficacy regarding mastery experience, vicarious experience and social persuasions were found to be sufficient. They held a low level of sources of self-efficacy regarding physiological state. Findings revealed that gender is not a distinguishing factor when explaining students' achievement emotions and sources of self-efficacy. A significant difference was found between students' achievement emotions and sources of self-efficacy regarding mathematics achievement. Results of the study revealed that achievement emotions and sources of mathematics self-efficacy were closely intertwined.

Morán-Soto and Benson (2018) conducted a mixed methods research study focusing on two relevant factors in students' decisions to pursue and complete an engineering major: mathematics preparation and

mathematics self-efficacy. The study describes the relationship of mathematics self-efficacy on engineering students' performance, behavior, and attitudes in their first college mathematics courses. 408 participants completed a mathematics self-efficacy survey and 11 participants were interviewed. The study examined participants' behaviors and attitudes in college mathematics courses, their mathematics self-efficacy beliefs, and how these beliefs aligned with their mathematics competence. Interview participants reported relatively high mathematics self-efficacy, but many revealed a mismatch between their mathematics self-efficacy beliefs and mathematics competence levels. Participants who had a balance between these two factors reported being more likely to spend extra time working to overcome their mathematics deficiencies and seeking extra help. However, participants with a mismatch reported being more likely to procrastinate and put little effort into improving their mathematics competence, blaming external factors for their struggles. Despite showing different behaviors and attitudes, all participants reported being likely to continue taking mathematics courses required for their major even after failing their first college mathematics course which does seem to be related to their mathematics self-efficacy.

Blotnicky, Franz-Odendaal, French and Joy (2018) conducted a study with 1,448 public school students in grades 7 and 9 in Atlantic Canada to explore students' knowledge of science, and mathematics requirements for science, technology, engineering, and mathematics (STEM) careers. Also explored were their mathematics self-efficacy (MSE), their future career interests, their preferences for career activities, and their likelihood to pursue a STEM career. The results of the study suggested that while older students had more knowledge about mathematics/science requirements for STEM careers, this knowledge was lacking overall. Also, students with higher MSE were more knowledgeable about STEM career requirements. Furthermore, students with higher MSE and STEM career knowledge were more likely to choose a STEM career. Students with greater interest in technical and scientific skills were also more likely to consider a STEM career than those who preferred career activities that involved practical, productive, and concrete activities. The researchers concluded that students in middle school have a limited STEM career knowledge with respect to subject requirements and with respect to what sort of activities these careers involve. Furthermore, students with low MSE have a declining interest in STEM careers. The findings in this study suggested that there is a need to improve access to knowledge to facilitate students' understanding of STEM careers and the nature of STEM work. Exposure of students to STEM careers can enhance their interest in pursuing careers involving science, technology, engineering, and mathematics.

Schöber, Schütte, Köller, McElvany and Gebauer (2018) conducted a study with 1,597 secondary school students in Germany to test for reciprocal effects between self-efficacy and achievement in the domains of mathematics and reading. The study revealed positive effects of mathematics self-efficacy on later mathematics achievement and of reading achievement on later reading self-efficacy.

Todor (2014) conducted a study with 108 college students aged between 14 and 18 years to investigate: (1) possible relationship between students' implicit theories of intelligence (i.e. whether intelligence or abilities can change) and their mathematics self-efficacy beliefs, and (2) gender differences in implicit theories of intelligence and mathematics self-efficacy beliefs. The results of the study suggested significant gender differences in both constructs (dominant implicit theory of intelligence and mathematics self-efficacy beliefs). Significant correlations between implicit theories of intelligence and mathematics self-efficacy beliefs were observed which suggests that students who have positive opinion about change in intelligence will also have higher mathematics self-efficacy.

How Can Mathematics Self-Efficacy be Improved?

Several studies also explored how mathematics self-efficacy can be improved. Masitoh and Fitriyani (2018) conducted a classroom action research by applying problem- based learning approach to improve students' mathematics self-efficacy. The classroom action research was done in two cycles. Each cycle consisted of planning, action, observation, and reflection. The findings of this research revealed that the problem- based learning approach could improve student's mathematics self-efficacy. At the end of the first cycle, the students' mathematics self-efficacy was still in the medium category and increased at the end of the second cycle, in which students' mathematics self-efficacy was in high category.

Conclusion

Considerable amount of empirical research focused on mathematics self-efficacy seeing it important for both students immediate and later success, for their career choice given the requirement of the time to prepare the workforce of tomorrow with appropriate STEM skills. While some studies attempted to find relationships with mathematics self-efficacy and other variables, a few of them also explore different types of instructional designs that could help improve students' mathematics self-efficacy. The practical value of this discussion for the district might be to explore mathematics self-efficacy in high school students and based on the research findings, design instruction that can help enhance students' mathematics self-efficacy. This can help orient graduating students towards STEM careers that the employment market is interested in filling in the current period.

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