DOI: 10.53469/jerp.2025.07(06).23

A Literature Review on Mathematical Creative Self-Efficacy and Mathematical Creativity

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Abstract: ***Due to the needs of societal development, mathematical creativity plays an increasingly important role in modern society. Understanding how to enhance mathematical creativity among junior high school students holds significant theoretical and practical implications for improving junior high school mathematics education. Creative self-efficacy is closely related to mathematical creativity. To enhance mathematical creativity among junior high school students, this paper reviews and analyzes literature on mathematical creativity and mathematical creative self-efficacy, identifies current research gaps, and provides references and suggestions for refining theoretical research.***

Keywords: Mathematical Creative Self-Efficacy, Mathematical Creativity, Self-Efficacy, Literature Review.

1. Introduction

Creativity can be traced back to the origins of humanity, as evidenced by ancient Chinese myths such as "Nuwa Mending the Sky" and "Kua Fu Chasing the Sun," which reflect early humans' challenges to nature and their pursuit of the future. Research during this period was imbued with philosophical awareness, marking the earliest manifestations of humanity's exploration and study of creativity. Since Guilford delivered his speech "On Creativity" in 1950, creativity has garnered increasing attention from scholars, marking the beginning of the scientific study of creativity. Since the 1980s, issues related to creativity have sparked strong reactions worldwide, and creativity research has seen significant new developments. In 2010, the International Group for Mathematical Creativity and Giftedness (MCG) was established, shifting international attention from professional mathematicians to elementary and secondary school students in the classroom. With the advent of the information age, creativity has increasingly become a core competitive advantage for both nations and individuals. From an individual perspective, creativity helps young people adapt to the rapid social and economic changes in the real world [1], serving as a key to realizing personal potential and pursuing personal achievements. From a national perspective, with rapid technological progress and intensifying international competition, innovation has become a focal point for all countries. Those who can cultivate more creative talent will gain a competitive edge in the fierce global competition. A nation's development requires creative talent, and the cultivation of such talent must begin at the primary and secondary education stages [2]. Since the new century, China's education sector has begun to promote quality education, with creativity at its core. Among all subjects, mathematics plays a pivotal role in cultivating students' creativity [3]. Since the new round of curriculum reform, China's basic education has faced some issues: teaching places too much emphasis on repetition and imitation, limiting students' ability to think critically and preventing them from developing independent thinking skills [4]. Therefore, improving students' mathematical creativity in basic education is of great practical significance.

In order to enhance students' mathematical creativity, numerous scholars both domestically and internationally have conducted in-depth research on this topic. Creative self-efficacy plays a significant role in mathematical creativity. Some scholars have found that creative self-efficacy can help students transform their creative potential into creative achievements [5]. Therefore, exploring the primary influencing factors of middle school students' mathematical creative self-efficacy holds significant importance for enhancing students' mathematical creativity.

2. Current State of Research

2.1 Mathematical Creativity

There is no unified and clear definition of mathematical creativity in the academic community. Some researchers believe that mathematical creativity is a combination of divergent and convergent thinking, while others distinguish between professional and school-level mathematical creativity [6]. Some scholars point out that students' mathematical creativity "not only includes creative processes and thinking results, but also creative personality and emotions, including innovative awareness" [7]. Xie Mingchu points out that mathematical creativity in primary and secondary school students has the following characteristics: the ability to raise new questions or propose unique solutions [8]. Some scholars have categorized and organized relevant literature from the past decade and found that researchers' definitions of mathematical creativity can be broadly divided into four perspectives: "individual trait perspective," "psychological process perspective," "outcome perspective," and "sociocultural perspective" [3]. Kwon et al. pointed out that the definition of mathematical creativity primarily includes two aspects: creating new knowledge and flexibly solving problems [9]. For example, some scholars define mathematical creativity as "generating new mathematical ideas or products" [10]. Additionally, some scholars have pointed out that mathematical creativity is a specific category of general creativity [11][12]. Therefore, like general creativity, mathematical creativity includes both cognitive and emotional outcomes. Among these, emotional outcomes include self-efficacy [13]. Zimmerman argues that self-efficacy is more important than any other non-cognitive factor in the field of mathematics [14].

To more accurately assess students' mathematical creativity, researchers have conducted in-depth studies on evaluation

methods for mathematical creativity over the years. Many researchers believe that mathematical creativity is the development of creativity from general to specific domains, so in empirical research, the assessment framework for general creativity can be adopted [11][12]. Balka attempted to measure mathematical creativity using the three key dimensions of general creativity [11], namely fluency, flexibility, and originality from Torrance's creativity tools [15]. These three evaluation criteria have also been acknowledged by numerous subsequent researchers [10][16]. Fluency refers to the ability to generate a large number of ideas, flexibility refers to the ability to generate various ideas, and originality refers to the ability to generate unusual ideas [17]. Among these, originality is the primary characteristic of creativity and is more decisive in determining creativity than fluency and flexibility [18][19]. Specifically, among these three criteria, fluency is at a lower level of creativity, merely reflecting the quantitative aspects of creativity; flexibility is at a higher level of creativity, This is because students with high flexibility are skilled at posing new and different types of questions or using different methods to solve problems, demonstrating the adaptability of their divergent thinking during problem-posing and problem-solving, thereby opening up new avenues for thinking; originality is at the highest level of creativity, manifested in students' ability to break through the limitations of conventional thinking, pose questions different from those of most others, or adopt solutions different from those of the majority to solve problems, reflecting innovative thinking [20].

2.2 Mathematical Creative Self-Efficacy

Bandura first introduced the concept of self-efficacy in social cognitive theory [21]. According to social cognitive theory, people's behavior can be predicted by their perceptions of their own abilities [22]. Most scholars both domestically and internationally view self-efficacy as a belief. For example, some scholars have pointed out that self-efficacy describes an individual's belief in their own abilities, and this belief influences the tasks an individual chooses to undertake, how those tasks are carried out, and the level of effort expended [23]. Cervone and Peake define self-efficacy as an individual's belief in their ability to successfully complete a specific task or achieve a specific goal [24], a definition that has been widely accepted by many researchers. In summary, self-efficacy is a belief that constitutes part of self-perception.

Since creative self-efficacy is an extension of Bandura's concept of self-efficacy and constitutes part of an individual's general self-efficacy [25], and given that research on the concept of self-efficacy is relatively well-established, most scholars have arrived at a similar definition of creative self-efficacy. Some scholars define creative self-efficacy as an individual's belief in their ability to generate novel, original, and appropriate ideas, solutions, or behaviors in specific contexts [23]. In short, creative self-efficacy refers to an individual's belief in their ability to produce creative outcomes [26]. In fact, all students have the potential to generate creative ideas [27], but if teachers do not provide education opportunities focused on creativity, students may develop lower self-efficacy and lose confidence in their ability to creatively solve problems [28].

There has been little research on mathematical creative self-efficacy both domestically and internationally. Bicer, Lee, and others defined mathematical creative self-efficacy as an individual's belief in their mathematical ability to generate creative ideas in mathematics [10]. In addition, few scholars have combined creative self-efficacy with the field of mathematics in their research.

2.3 Factors Influencing Mathematical Creative Self-Efficacy

Since there are few studies on the factors influencing middle school students' mathematical creative self-efficacy, and mathematical creative self-efficacy is the development of creative self-efficacy in a specific field, the scope of the search was expanded to include factors influencing creative self-efficacy. After analysis and summarization, it was found that the factors influencing middle school students' creative self-efficacy mainly include the following aspects.

2.3.1 Student Personal Aspects

Some scholars have conducted a systematic review and analysis of domestic and international literature and found that individual factors significantly influence creative self-efficacy [23]. Beghetto conducted a study on students with an average age of 14 and found that students' creative self-efficacy is related to their achievement goal orientation [25]. Achievement goal orientation refers to the achievement goal orientation that individuals rely on when participating in a particular activity, specifically including mastery approach goals, mastery avoidance goals, performance approach goals, and performance avoidance goals. In Beghetto's study, only mastery approach and performance approach were positively correlated with students' creative self-efficacy, while mastery avoidance and performance avoidance showed no significant correlation with creative self-efficacy. This finding aligns with the results of Tan, Li, and Neber's research [29].

Academic beliefs and extracurricular activities also influence students' creative self-efficacy [25]: Students with high creative self-efficacy are more likely to believe they perform well in mathematics and have higher participation rates in extracurricular activities. Tan, Li, and Neber noted that positive aspects of creative personality (such as openness, extroversion, and self-awareness) are positively correlated with students' creative self-efficacy. Additionally, within the same culture, individualism is a stronger predictor of students' creative self-efficacy than collectivism [29].

2.3.2 Teachers Aspects

Some scholars have found through questionnaire surveys that teachers' creative teaching behaviors significantly and positively predict students' creative self-efficacy [30]. Additionally, teachers' encouragement of creativity has a significant impact on students' creative self-efficacy [31]. Bandura also noted in his research that self-efficacy is cultivated through feedback related to ability. Students' creative self-efficacy is associated with teachers' feedback on students' creativity in classroom experiences: when students feel that teachers are indifferent to them or have given up on

them, their creative self-efficacy often decreases [25].

2.3.3 Tasks Aspects

The difficulty of the task also affects students' mathematical creative self-efficacy. In mathematical problem-posing tasks, students often judge their ability to pose problems based on the difficulty of the task rather than their actual performance [32]. In other words, students' mathematical creative self-efficacy is higher in simple tasks than in difficult tasks.

3. Literature Review

As evidenced by existing literature, significant progress has been made in the study of mathematical creativity and its evaluation methods. Additionally, there is a wealth of literature on self-efficacy and creative self-efficacy. Furthermore, some scholars have investigated the factors influencing creative self-efficacy among junior high school students, focusing primarily on three areas: students themselves, teachers, and tasks. These studies have broadened the scope of this research and provided valuable research texts and materials. However, a review of previous domestic and international research reveals that studies on creative self-efficacy among junior high school students in the field of mathematics are scarce, and the study of influencing factors also failed to identify the main influencing factors. Furthermore, Bandura mentioned in his motivation theory that the influencing factors of self-efficacy include personal success and failure experiences, vicarious experiences, verbal persuasion, and emotional arousal [21]. Since mathematical creative self-efficacy is an extension of self-efficacy, the factors influencing self-efficacy may also affect students' mathematical creative self-efficacy. However, previous studies have not explored whether personal success and failure experiences, vicarious experiences, and emotional arousal have a primary influence on students' mathematical creative self-efficacy. Therefore, future research should focus more on mathematical creativity self-efficacy, conducting in-depth analyses and comparisons of its influencing factors to identify the primary factors, and proposing actionable recommendations targeting these primary factors. This would be beneficial for enhancing middle school students' mathematical creativity and improving educational quality.

4. Conclusion

Overall, there have been some achievements in research on mathematical creativity and creative self-efficacy both domestically and internationally. However, there has been little research on creative self-efficacy among junior high school students in the field of mathematics, and no major factors influencing creative self-efficacy in mathematics have been identified among the factors affecting creative self-efficacy. In addition, compared with foreign countries, there has been little empirical research on the factors influencing creative self-efficacy in mathematics among junior high school students in China. Therefore, related research in China still needs to be improved and supplemented.

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