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Creative behaviours in mathematics: Relationships with abilities, demographics, affects and gifted behaviours

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ABSTRACT

This study aims to identify key creative behaviours in mathematics and to investigate the relationships of the identified behaviours with mathematics achievements, demographics, mathematics affects, and general gifted behaviours. The research participants were 372 Grade 4 students. The results of exploratory and confirmatory factor analyses identify 5 key creative behaviours in mathematics: representation invention, component association, outcome improvement, alternative curiosity, and space imagination. The results of correlation analyses reveal that component association and outcome improvement relate to mathematics achievements, reasoning, and creativity. The 5 creative behaviours have few relationships with gender, gifted education experiences, and parent education, but many relationships with mathematics affects and general gifted behaviours. The identified key creative behaviours can be used to design effective pedagogies for promoting student creativity in mathematics.

1. Introduction

Creativity in mathematics is traditionally viewed as one of the most important characteristics of professional mathematicians but narrowly conceptualized by mathematics teachers (Bolden, Harries, & Newton, 2010). Recognizing student multiple creative behaviours based on the multiple characteristics of 'big' creators in mathematics may broaden the conception of 'mini' creators (students) in mathematics classrooms (Beghetto & Kaufman, 2009, p. 42). Carlton (1959) analyses the writings of 14 creative mathematicians during the period of 1790–1940 and identifies 21 characteristics of creative behaviours. The 21 creative behaviours may need to be empirically validated based on student responses and to be reduced in quantity in order to facilitate the development of operational pedagogy for mathematics education.

The purpose of this study therefore is to identify key creative behaviours in mathematics learning based on the perspective of multiplicity in creativity and drawing on the characteristics of creative mathematicians obtained by Carlton (1959). Further, this study will investigate the relationships between the identified behaviours and relevant student characteristics to deepen the understanding of the identified behaviours. The findings of this study are likely to advance the knowledge of multiple creative behaviours in mathematics learning and facilitate suitable pedagogies for cultivating student creativity in mathematics.

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1.1. Multiple creative behaviours in mathematics

Student or mathematician self-reports on creative behaviours in mathematics can be viewed as multiple creative dispositions or strategies towards mathematics with novel meanings, discourses, or stories that they construct based on their relationships or negotiations with mathematical experiences in their lived field (Di Martino & Zan, 2011; Nolan, 2012; Pepin, 2011). Most studies on creative behaviours in mathematics focus on creative problem solving and suggest that creative behaviours include diverse attributes such as divergent thinking, convergent thinking, motivation, and environment (Lin & Cho, 2011). Some studies extend the scope from problem solving to posing and view creative behaviours in mathematics as continuous, cognitive processes from problem-solving, mediated by transformation (decoding, representing, processing, and implementing), to problem posing and vice versa (Singer & Voica, 2013).

Creative behaviours in general creative thinking may include both cognitive (procedural and conceptual knowledge) and affective (emotions, moods, traits, and dispositions) components followed by the creative process of frame construction, situation consideration, learner understanding, and stream negotiation (Newton, 2013). The creative process may include attentional behaviours such as orienting sensitivity and effortful control (Lin, Hsu, Chen, & Chang, 2013) and can be categorized into fast (automatic) and effortful (logical) thinking (Allen & Thomas, 2011). Relatively few studies on creativity focus on cross-process strategies, skills, and behaviours such as cause analysis, association production (Acar & Runco, 2014), error identification, constraint management (Mumford, Medeiros, & Partlow, 2012), reproduction, creative imagination (Liang, Chang, & Hsu, 2013) and application preparation (Barrett et al., 2013). Thus, this study will focus on the issue of cross-process creative behaviours.

1.2. Diverse learning results in mathematics and relationships with creative behaviours

Student learning results need to be understood by different tasks such as closed-ended (one solution) tasks, reasoning tasks (Lithner, 2008), and open-ended (multiple solutions) creative tasks. Relationships between student learning results based on school achievement tests and creativity tests may vary dependent on learning contexts (Gralewski & Karwowski, 2012) and domains. For example, mathematics creativity relies on achievements (Sak & Maker, 2006) more than art creativity (Jeon, Moon, & French, 2011). Mathematics educators often assess cognitively creative results in mathematics with the components of general creativity such as fluency, flexibility, originality, and elaboration (Kwon, Park, & Park, 2006; Lev-Zamir & Leikin, 2011). Problem posing tasks are often used to assess student creativity in quantity (fluency) and quality (novelty and elaboration) (Bonotto, 2013; Van Harpen & Sriraman, 2013).

Creative behaviours in mathematics may have different relationships with diverse student learning results in mathematics. Livne and Milgram (2006) indicate that student general creative behaviours (thinking) relate to student creativity in mathematics but not to student achievement in mathematics. Mann's (2009) study, however, shows that student mathematics talents and general creative behaviours assessed by teachers relate to both student mathematics achievement and creativity.

1.3. Relationships of creative behaviours in mathematics with demographics, mathematics affects, and gifted behaviour

Research has shown that student mathematics talents and general creative behaviours assessed by teachers are not related to gender (Mann, 2009). Domain-specific creative tasks, however, may slightly favour specific genders. For example, interpersonal and history tasks may favour females (Hong & Milgram, 2010; Hong, Peng, O'Neil, & Wu, 2013). Socio-economic status (SES) such as parent education may take a role, mediated by achievements and creativity-related psychological traits (e.g., confidence and motivation), in student creativity (Dai et al., 2012).

Student self-report affects in mathematics relate to student mathematics talents and general creative behaviours assessed by teachers (Mann, 2009). Research on general creativity also indicates likely relationships between the personality trait of openness and the interest in some domains (e.g., poems but not pictures) (Silvia & Sanders, 2010). Inducing positive affects, such as fun and happiness, may increase creative thinking and production (Fernández-Abascal & Díaz, 2013).

The relationships of gifted behaviours with creative behaviours appear to be an intuition because giftedness is normally conceptualized as including creativity (Kaufman, Plucker, & Russell, 2012). Student mathematics talents relate to their general creative behaviours although both of the 2 measures are assessed by teachers (Mann, 2009). Self-report creative behaviours and achievements also relate to self-report creative personality traits such as openness (Batey, Furnham, & Safiullina, 2010).

Based on the above review of literature, this study aims to answer the following research questions:

1. What are the key creative behaviours in student mathematics learning?
2. Are there relationships between student creative behaviours and mathematics abilities in terms of mathematics achievements, reasoning, and creativity?
3. Are there relationships of student creative behaviours with demographics, mathematics affects, and general gifted behaviours?