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Influence of Thinking Style on the Critical Thinking Skills and Creativity in Mathematics

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Abstract

Two of the key talents that students need to possess in the twenty-first century are the ability to think critically and creatively, both of which can be nurtured through mathematics training. Teachers should take into account the various ways that each student thinks when using pedagogical strategies to help students develop their critical and creative thinking abilities in mathematics. Thus, the main goal of the study was to determine whether there were any significant differences in the critical thinking and creativity abilities in mathematics among the various thinking styles of Grade 10 students in a national high school in the Philippines. In order to compare the differences between the critical thinking skills and creativity of sixty respondents in mathematics depending on their thinking styles—inchworm and grasshopper—a comparative descriptive research design was used in the study. The results showed a significant difference in the critical thinking skills in mathematics as to interpreting information component only of critical thinking skills. Furthermore, thinking style is not a determinant in students' mathematical creativity due to non-existence of significant difference. The study recommends that teachers consider students' thinking styles when developing instructional materials and strategizing their instruction because this helps students interpret information and decide whether the evidence and conclusions obtained from mathematical problems can be generalized. To confirm the study's conclusions, a similar study with a high number of respondents for each thinking style is recommended.

Keywords: *thinking style, grasshopper, inchworm, critical thinking skills, mathematical creativity*

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1. Introduction

Current and prospective learners will be needed to meet a new set of requirements that are considered as quality indicators and key factors for future success as society goes further into the twenty-first century and focuses on becoming more globalized. According to the National Education Association (2014), these are the "Four Cs" of 21st-century abilities which stand for critical thinking, collaboration, communication, and creativity. Critical thinking and creativity are two of these skills that may be cultivated through problem-solving (Starko, 2017; Kholid et al., 2020), and students learn how to solve problems in mathematics (DepEd, 2016). Mathematical problem solving stimulates pupils' mental processes. Each student has a unique approach to acquiring their lessons, absorbing their teacher's knowledge, and then implementing what they have learned. This is related to cognitive thinking style since it relates to how pupils acquire and process information (Susandi & Widyawati, 2017).

Mathematical problem solving is inseparable from the capacity for critical thinking. whereas cognitive (thinking) style can influence critical thinking (Kholid et al., 2020). Each individual has a distinct personality, and this distinction motivates students to consider in a variety of ways when providing an idea or solution to a particular response. Mathematical problem-solving is the response in question (Susandi & Widyati, 2017). There are two styles of mathematical thinking labeled as "*inchworm*" thinking style and "*grasshopper*" thinking style. An inchworm-style of problem solving involves formulas and memorized step-by-step methods, but grasshopper-style takes a global approach by looking at the broader picture to arrive at the answer (Chinn, 2013). A learner's processing of information and mental reflection on concepts is characterized by their thinking styles. Hence, each thinking style plays an imperative role as this serves a students' preference in processing information (Soleh, 2017). It just implies that intervention should be considered depending on their thinking style, and intervention should be actively aware of how the learner thinks (Chinn, 2016).

Some of the factors that contribute to students' poor critical thinking abilities include a lack of pedagogy in critical thinking in the classroom (Rahayu, 2020), and the absence of learning innovations that aids students to think systematically (Rivers & Kinchin, 2019). As a result, the Philippines was ranked 57th out of 63 economies in the World Talent Ranking measured by the International Institute for Management Development (IMD) World

Competitiveness Center in 2021 and 54th in 2022, which the institute believes was due to poorer performance by other economies (IMD World Competitiveness Center, 2021; IMD World Competitiveness Center, 2021). In 2021 and 2022, it was placed 13th out of 14 Asia Pacific economies, with Singapore, Australia, and Hong Kong occupying the top three spots. Due to a serious lack of critical thinking skills among students, the Philippines has to improve its educational system to make its future workers more competitive on the global market (Ibanez, 2020).

As stated by Firdaus et al. (2015), it is mandatory for the teachers to gauge and foster students' critical thinking skills during classroom discussion. The development of students' capacities for critical thinking needs to be a central focus of education. However, students have not been able to effectively cultivate this gift. Currently, math educators play crucial responsibilities for this matter (Fong et al., 2017).

Creativity is also given emphasis as one of the top skills stated by World Economic Forum as this is essential for success in the workplace and highly sought after by employers (Whiting, 2020). Robinson (2015) perceives that only through creative experiences will our children be able to prepare for the ever-changing environment they must face. Learning activities that promote creativity position students in the roles of problem solvers and communicators rather than passive information acquirers (Starko, 2017). According to Walia and Walia (2017), the deductive approach of teaching is widely employed in most schools and does not allow students to think in a divergent manner. Students must solve problems using the formula as suggested by the teacher. When asked to uncover creativity in mathematics among pupils, mathematics teachers have no idea since they believe that just one answer exists for a specific question in mathematics. It is necessary to provide some issues and scenarios for pupils in order to stimulate their creativity (Walia & Walia, 2017). Since creative thinking is one of the 21st-century skills that gives motivation, drive, and strength in the face of the industrial revolution (Yuliati et al., 2018), schools need to prioritize it in order to solve the low level of creative thinking abilities among students (Ulfa, 2018).

The difficulties to think critically can make it difficult to think mathematically and creatively. Learning math requires the growth of creative thinking abilities. Hence, mathematics teacher must convey the need for applying creativity to mathematical activities before the development of mathematical creativity at school (Grégoire, 2016). According to researchers, students' critical and creative thinking both grow as they learn (Chang et al., 2015). Thus, creative and critical thinking work best together in the establishment of quality innovations and the sustainability of education. These skills must be critically developed during the instructional design process in order to achieve global competitiveness (Birgili, 2015).

Meanwhile, multiple researches linked thinking style to critical thinking skills (Birgili, 2015; Kim & Song, 2013; Rifqiyana & Susilo, 2016; Siburian & Saptasari, 2019; Firdaus et al., 2015), as well as creativity (Purnomo et al., 2021; Tam et al., 2022; Wijaya, et al., 2016). Abdi (2012) asserts that there is a strong correlation between critical thinking and thinking style. There is evidence that certain thinking styles have a significant impact on critical thinking skills. However, the thinking style assessment used is not meant for mathematics education. Additionally, mathematical creativity is not taken into account in the previous investigations. On the other hand, Purnomo et al. (2021) concluded that a person's capacity for creative and critical thinking is not only impacted by their thinking style and that academic success in mathematics does not always indicate a person's capacity for these traits. On the other hand, Singer et al. (2017) confirmed that a specific thinking style is a good predictor of mathematical creativity while Piaw (2014) asserted that thinking style, along with gender, were important predictors of creative thinking abilities. Individuals with different cognitive styles used various strategies in creative mathematical tasks (Pitta-Pantazi et al., 2013).

These contradictory results from earlier studies imply the need for further studies. Hence, this study argues the need to find any significant difference on critical thinking and creativity in mathematics when students are classified according to their thinking styles. This research also looked into the following hypotheses:

Ho1: There is no significant difference that exists in the level of critical thinking skills of the students when they are grouped according to their thinking styles.

Ho2: There is no significant difference that exists in the level of mathematical creativity of the students when they are grouped according to their thinking styles.

2. Literature Review

2.1. Thinking styles and mathematical thinking styles

According to Chinn and Ashcroft (2016), a person's "cognitive style" (or thinking style) in mathematics refers to how they approach an issue. The majority of the time, teachers may detect a student's thinking style by simply observing him as he works. The use of creative learning materials, art of questioning and flexible instruction can be employed to sustain students' interest in mathematics based on their thinking style. Furthermore, the use of thinking style can help students analyze word problems and strengthen links and interconnections between numerical facts and operations. Variation in the teaching strategies and approaches is beneficial for the students who demonstrate gaps in learning and the intervention must be actively cognizant of how the learner thinks (Chinn, 2016).

When a problem is presented by the teacher, a learner with an inchworm thinking style will demonstrate sequential thinking by developing one solution. On the other hand, a learner with a grasshopper thinking style exhibits holistic thinking, in which the learner concentrates on a deeper degree of understanding on a specific lesson and assimilates new concepts into past knowledge to further accomplish conceptual learning (Chinn, 2013). Students with an inchworm thinking style have an advantage in school because evaluation processes place a higher value on analytic thinking (Huincahue et al., 2021; Chinn, 2016). Thus, success is more favorable to inchworm than grasshopper because the former thinking style matches the demand of environment (Kovalcikiene et al., 2013). One reason for this is that successful sequential thinkers in mathematics have more working memory capacity than grasshoppers, especially for formulas and methods to be employed in specific items (Chinn, 2013). According to Batool and Saeed (2019), working memory capacity has a substantial link with student's mathematical performance, implying that higher working memory capacity leads to greater academic achievement in mathematics. Furthermore, working memory is a crucial predictor of academic learning and accomplishment (Friso-van den Bos & Van de Weijer-Bergsma, 2020). Meta-cognition, sometimes known as "knowing about how you know," is the process of comprehending and being aware of how you think. It is closely related to thinking style. By establishing learning objectives and monitoring students' advancement toward achieving them, a "metacognitive" approach to instruction will result to independent learning. In this sense, cognitive flexibility of learners should be given sufficient attention in creating instructional materials and implementing teaching pedagogies (Chinn, 2013, 2016).

The two teaching methods, behavioristic and constructivist, represent the ever-swinging pendulum of teaching ideas. These two cognitive styles appear to correspond to the inchworm and grasshopper cognitive styles. The behavioristic focuses on skill development, develops a single algorithm, memorizes and follows a specific method, masters skills prior to application. Further, it is more advantageous in individualized drill and rehearsal activities for mastery. On the other hand, the constructivist focuses on a deeper level of comprehension, concentrates on the variety of resources and activities, interacts with materials for an increased conceptual learning, and assimilates new concepts into prior knowledge. The inchworm learner will benefit from the behaviorist learning style, whereas the grasshopper learner will benefit from the constructivist learning style. In the ideal scenario, appropriate and balanced applications of both thinking and teaching approaches would be made (Chinn, 2013).

According to Kovalcikiene et al. (2013), students perform better when the thinking patterns are compatible with the demands of the educational environment than the counterparts. According to Zakariya (2022), self-efficacy is one of the personality factors that affects how well students perform mathematically. Self-efficacy can be defined as a person's belief in their own ability to carry out a task or achieve a goal that they have set for themselves. It is the belief that a person has in their ability to manage their conduct, exercise control over their environment, and keep their motivation up during the process of working toward reaching a goal (Cherry, 2023). According to Komarraju and Nadler (2013), students who are capable of successfully regulate their feelings and remain resilient in the face of challenges are more likely to achieve academic achievement.

It is important to note that mathematics education prefers students to learn mathematics rather than how well they are at learning mathematics. In this connection, assessing the mathematical thinking styles of student is significant due to the negative impact it brings on students' self-efficacy particularly if the thinking styles do not match the style required by the educational environment (Honicke & Broadbent, 2016). Students' dread of inadvertently recalling inaccurate responses in a classroom context may set off a chain reaction of quick scorn from their classmates, discouraging many of them from engaging in future classroom discussions (Bowie, 2018).

2.2. Critical thinking skills

The skills essential to see beyond various things or concepts to find the common value that connects them are used by students who are trained to think critically (Yousefi & Mohammadi, 2016). The educational programs incorporate the critical thinking, creative thinking, and problem-solving skills that are necessary in today's environments (Gini-

Newman & Case, 2018; Gray, 2016). According to Muhlisin et al. (2016), lack of critical thinking skills is related to a traditional teaching method. Students are limited to using a single answer, which limits their ability to explore ideas and other solutions, resulting in poor critical thinking skills (Haber, 2020). Students' critical thinking will suffer in an uncritical learning environment. In order to develop thinking students rather than regurgitators of knowledge with a narrow perspective, class activities should promote students' cognitive ability and higher order thinking skills (Fadhlullah & Ahmad, 2017).

For students to succeed in the future, critical thinking skills are necessary (Firdaus et al., 2015). As the educational system aims to produce future leader who can think critically, these skills should be given emphasis in the entirety of the teaching and learning process. Exposure to several mathematics activities that challenge students may help to refine their critical thinking abilities. Lack of critical thinking skills hindered students' analytical abilities to make conclusions, adjust to higher-level thinking, and identify truths and facts (Taleb & Chadwick, 2016). Consequently, only a few pupils are able to interpret information and synthesize evidence from issues. Due to differences in perspectives, incomplete data leads to an incorrect conclusion (Chasanah, 2019).

2.3. Mathematical creativity and creative thinking

Mathematical creativity is undeniably an essential element in today’s generation (Barraza-Garcia et al., 2020; Isnani et al., 2020; Pitta-Pantazi et al., 2013). Students today frequently memorize shortcuts for solving mathematical puzzles without comprehending the underlying concepts (Tubb et al., 2020; Roslan et al., 2021). Every student may be creative when given the right conditions, and teachers expect them to solve arithmetic problems more effectively and creatively (Kozlowski et al., 2019). Enhancing mathematical creativity paves the path for the inspiration, encouragement, and motivation of all students.

According to math educators, fostering innovative thinking in children through a creative learning technique can increase their creativity for mathematics (Hamid & Kamarudin, 2021). In order to solve mathematical issues or generate new ideas, creative thinking is required (Hadar & Tirosh, 2019). This process comprises identifying and changing something's most recent regular traits (Perry & Karpova, 2017). As mentioned by Alismail and McGuire (2015), using creative thinking can also enable students to draw fresh and meaningful conclusions from their activities and experiences. Furthermore, creative thinking as a cognitive talent is critical for pupils to understand the outcomes of a novel concept or solution (Sitorus, 2016). Students should be able to think creatively in math, which is typically based on an underlying process or something that has been produced. As a result, examinations to assess mathematical creative thinking abilities should be included in educational courses.

3. Methodology

3.1. Research design

The descriptive-comparative research design was used in this study. According to Cantrel (2011), the purpose of this study is to describe the differences between groups in a population without manipulating the independent variable. Therefore, in this study, the existence of significant differences in critical thinking and creativity in mathematics was examined when they were grouped based on their thinking styles.

3.2. Respondents of the study

The population of the study were Grade 10 students from 5 heterogeneously grouped sections. They were composed of 112 male students and 89 female students and the researcher classified the respondents through determining their thinking style through the cognitive (thinking) style test by Bath et al. (1896). They were classified as respondents with inchworm thinking style or grasshopper thinking style.

3.3. Sampling technique

The respondents for this study were chosen using the purposive sampling technique. This sort of non-probability sampling technique, according to Nikolopoulou (2022), picks respondents based on the attributes required in the sample. The researcher classified the population in this study based on their style of thinking as defined by Chinn (2013). The respondents of this study were those students who had the most dominant signs of inchworm and grasshopper thinking styles, thirty (30) students for each thinking style, among the population.

3.4. Research Instrument

The study adopted the cognitive (thinking) style test by Bath et al. (1986) to determine the thinking styles of the respondents from the population. Afterwards, the respondents answered a researcher-made mathematical creativity test. Subsequently, the respondents answered another researcher-made critical thinking test to measure their critical thinking skills. The acceptability of the mathematical creativity test was determined using a 4-point Likert scale to measure the appropriateness of the word problems in measuring mathematical creativity in terms of fluency, flexibility, and originality. Five word problems were chosen with 'highly appropriate' rating in terms of content validity from the ratings, comments, and suggestions of the validators. Moreover, the acceptability of the critical thinking test was determined with a 4-point Likert scale to measure the appropriateness of the word problems in measuring critical thinking skills of the respondents in terms of inferences, recognition of assumptions, deductions, interpreting information, and evaluation of arguments. All of the word problems were given a 'highly appropriate' rating in terms of content validity.

3.5. Research procedure

The researcher prepared the necessary letters for the conduct the study and explained the purpose of the study to the administrators as well as the respondents. Ethical considerations were observed to ensure confidentiality and anonymity of respondents. After approval, the researcher identified the population with inchworm thinking style and grasshopper thinking style by answering the cognitive (thinking) style test. This test was divided into four days with three items per day in order to prevent the respondents from feeling anxious while answering the test. As part of the purposive samples, the top thirty respondents who had dominant percentage of inchworm thinking style as well as the grasshopper thinking style were qualified to answer the mathematical creativity test. In this phase, one-word problem per day was given to prevent anxiety from the respondents while answering the test. Afterwards, the respondents answered the critical thinking test to measure their critical thinking skills with one component of critical thinking test per session.

After implementation, the researcher compiled all the responses and gathered all the needed data. The data gathered from the test of cognitive style in mathematics was scored based on Chinn's (2016) rubric for scoring the test. Mathematical creativity was scored using the scoring rubric adapted from Andrade and Pasia (2020). The data gathered from the critical thinking test was scored based on correct responses through the researcher-made scoring rubric. After checking, the scores of the respondents were summarized and independent t-test was used as statistical treatment for the scores. To guarantee the normality of the distribution, the study used Shapiro Wilk Test which has a p-value of 0.583. The goal of Shapiro Wilk Test is to compare two distributions to determine if they are pulling from the same underlying distribution. With this, the parametric tests used were deemed suitable for the conduct of this research.

4. Findings and Discussions

Table 1

Test of difference in the critical thinking level

Critical Thinking	Inchworm		Grasshopper		T	Df	Sig. (2-tailed)
	Mean	SD	Mean	SD			
Inferences	3.67	0.81	3.67	0.98	.029	58	.977
Assumptions	3.45	0.82	3.13	0.73	1.594	58	.116
Deductions	3.40	0.84	3.30	0.99	.421	58	.675
Interpreting Information	2.30	0.49	2.03	0.47	2.189	58	.033
Arguments	2.53	1.14	2.60	0.97	-.244	58	.808

Table 1 compares the critical thinking levels of inchworm and grasshopper respondents. The table shows that both thinking styles have the same mean score for inferences (3.67), but the inchworms have a higher mean for critical thinking in terms of recognition of assumptions (3.45 for inchworms, 3.13 for grasshoppers), deductions (3.40 for inchworms, 3.30 for grasshoppers), and interpreting information (2.30 for inchworms, 2.03 for grasshoppers). In comparison to the inchworms, the grasshoppers had a better advantage in terms of evaluating arguments (2.53 mean for inchworms, 2.60 mean for grasshoppers) since they had a higher mean.

The inferences questions are made up of shapes and figures, and respondents must look for a specific pattern in order to draw a conclusion from the presupposed information on the specific shapes and figures. The inchworms had an advantage because of their adept focus on details and parts of the specific shapes and figures. On the other hand, the grasshoppers found it easier because they were able to understand the relationships of the figures to their corresponding numerical values because of their ability to 'trial and adjust' when deciphering the numerical values of the particular items to solve for the correct answer. Students with strong problem-solving skills tend to think more critically, which helps them achieve their goals in practically all areas of life (Bhat, 2016). This further substantiates Chukwuyenum's (2013) assertion that in order to arrive at a trustworthy and accurate conclusion, critical thinking requires the effort of information gathering, interpretation, analysis, and evaluation. Mathematical problem solving and critical thinking are intricately related.

The table also shows that there is no significant difference between the inchworm and grasshopper thinking styles and inferences, recognition of assumptions, deductions, and argument evaluation. This suggests that the thinking style does not help the inchworm and grasshopper respondents' critical thinking skills in areas of making inferences, recognition of assumptions, deductions, and evaluation of arguments. According to Purnomo et al. (2021), if there is no substantial difference, someone's critical thinking capacity is influenced by factors other than cognitive style. Furthermore, good mathematics academic aptitude is not always an indication of high critical thinking ability (Purnomo et al., 2021), which suggests that students' thinking styles cannot be a key component in determining their critical thinking skills.

However, there is a significant difference in thinking styles and interpreting information between the inchworm and grasshopper, with a p-value of 0.033. It also revealed that the inchworms have a higher mean (2.30 mean) than the grasshoppers (2.03 mean). This suggests that there is a significant difference in the grasshopper and inchworm thinking styles and critical thinking when it comes to interpreting information. This also implies that thinking styles play an important role in determining whether the evidence and conclusions derived from word problems can be generalized and in examining how something will be done to reach a result. Cosku (2018) defines a learner's thinking style as their processing of knowledge and mental reflection on concepts. As a result, each thinking style is important since it serves a student's preference in processing information (Soleh, 2017), and cognitive (thinking) style can influence critical thinking (Kholid et al., 2020). This validates the most current study by Abdi (2012) that thinking style influences critical thinking; however, this study was released more than ten years ago, and no other studies have been published in recent years.

Consequently, despite the absence of significant differences between thinking styles and critical thinking skills, it is imperative for educators and prospective educators to undertake the responsibility of cultivating and evaluating the critical thinking aptitude of pupils during the course of instruction and acquisition. Firdaus et al. (2015) posit that the acquisition of critical thinking skills is imperative for students to achieve success in their future endeavors. The integration and cultivation of critical thinking abilities throughout the fundamental curriculum, pedagogy, and educational practices are imperative for the production of proficient and visionary students who can become future leaders. Hence, it is imperative to cultivate the critical thinking abilities of students across all academic disciplines, with a particular emphasis on mathematics. According to Aybek and Yolcu

(2018), the classroom is a crucial environment for promoting and instructing critical thinking in a systematic and structured manner, thereby fostering a lifelong skill.

Table 2

Test of difference in the mathematical creativity level

Mathematical Creativity	Inchworm		Grasshopper		T	Df	Sig. (2-tailed)
	Mean	SD	Mean	SD			
Fluency	4.08	0.67	3.79	0.89	1.441	58	.155
Flexibility	2.84	0.36	2.59	0.65	1.867	58	.067
Originality	2.98	0.82	3.13	1.20	-.553	58	.582

Table 2 shows the difference in mathematical creativity levels between inchworm and grasshopper respondents. The inchworms (4.08 for fluency; 2.84 for flexibility) have a higher mean of mathematical creativity in terms of fluency and flexibility than the grasshoppers (3.79 for fluency; 2.59 for flexibility), but the grasshoppers (3.13 for originality) have a higher mean of mathematical creativity than the inchworms (2.98 for originality). This suggests that inchworms have a better level of mathematical creativity than grasshoppers. In terms of fluency and flexibility, inchworms are more mathematically creative than grasshoppers, who are more mathematically creative in terms of originality. According to Nami et al. (2014), higher levels of creativity for pupils boost their academic accomplishment, which explains why the inchworm respondents outperform the grasshopper respondents. Furthermore, Huincahue et al. (2021) verified that students with an analytical thinking style, such as inchworms, have an advantage in school because the evaluation systems place a larger value on analytic thinking. These successful sequential thinkers in mathematics have better working memory capacity than grasshoppers, notably for formulas and methods employed in the mathematical creativity test (Chinn, 2013). According to Batool and Saeed (2019), working memory capacity has a substantial link with student mathematical performance, implying that higher working memory capacity leads to greater academic achievement in mathematics. Another reason is that inchworm respondents outperform grasshopper respondents in terms of academic achievement. This supports the assertion of Huincahue et al. (2021) that inchworms (analytical thinkers) outperform grasshoppers (visual thinkers) in academic performance since mathematical references in schools are primarily formal-oriented and many teachers prefer the Inchworm thinking style. Furthermore, according to Friso-van den Bos and van de Weijer-Bergsma (2020), working memory is a major predictor of academic learning and accomplishment, giving the inchworm a competitive advantage.

The results also demonstrate that there is no significant difference in mathematical creativity between inchworm and grasshopper thinking styles in terms of fluency, flexibility, and originality. This shows that the respondents' levels of mathematical creativity in terms of fluency, flexibility, and originality were unaffected by their thinking styles. This implies that pupils' thinking styles cannot significantly influence how creative they are with mathematics. This is in line with the findings of Purnomo et al. (2021) that a person's capacity for creative thinking is influenced by factors other than cognitive style and that strong academic aptitude in mathematics is not always a reliable indicator of creative ability.

Enhancing students' mathematical creativity should be one of the teachers' primary focuses in their students' learning. According to Walia and Walia (2017), most schools adopt the deductive method of teaching, which does not allow students to think creatively. When asked to uncover originality in mathematics among pupils, mathematics teachers have no notion since they believe that just one answer exists for a specific question in mathematics. With this, this study supports Walia and Walia's (2017) claim that it is necessary to set up some challenges and situations for pupils in order to encourage creativity. Teachers are urged to try out with several teaching approaches rather than being limited to one. According to Chinn (2013), the behavioristic teaching style benefits the inchworm learner while the constructivist teaching style benefits the grasshopper learner. Learners must have cognitive flexibility to access both types, and teachers must be aware of and teach both styles (Chinn, 2013; Chinn, 2016). Because thinking styles have a big impact on achieving learning objectives, students need to be aware of each other's thinking patterns in order to discover their own potential. The teacher must be aware of the student's thinking style in order to enhance learning. It is hoped that educators will be able to determine the most effective method and technique for overcoming different difficulties in the learning process, which will improve learning outcomes (Rohman, 2017).

5. Conclusion

This study found a significant difference between students' thinking styles and critical thinking skills in terms of the interpreting information component of critical thinking. However, there is no significant difference between the Inchworm and Grasshopper thinking styles and critical thinking skills of students in terms of making inferences, recognition of assumptions, deductions, and evaluating arguments. Furthermore, there is no significant difference between the inchworm and grasshopper thinking styles and mathematical creativity of students in terms of fluency, flexibility, and originality.

The study recommends teachers to consider students' thinking styles when developing learning activities that promote critical thinking as to interpreting information, which involves analyzing how something will be done to draw a conclusion and reason to believe that it is the correct answer or solution. When planning learning activities and classes, it is also important to consider how to develop mathematical creativity. The study encourages teachers to be less confined by one sort of teaching style and to increase cognitive flexibility in subject instruction.

Future researchers may do a similar study on homogeneous classes and/or a different year level to validate the results with a larger sample size for each thinking style. This can pave the way for more effective teaching and learning that encourages students' critical thinking and mathematical creativity.

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