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Mathematical Creative Thinking and Differences in Students' Cognitive Styles in Learning Achievement: A Systematic Literature Review

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Abstract

The purpose of this article is to explain how students' varied cognitive styles and the outcomes of their mathematical creative thinking interact. The Systematic Literature Review (SLR) method. To find, examine, assess, and interpret all of the research that is currently available on the topic of interest, the SLR technique is employed. All publications pertaining to mathematical creative thinking and cognitive style in student learning achievement are compiled and reviewed in order to gather data. The international journals used were 5 which only focused on Scopus. The results showed that creative thinking can be strengthened in the science curriculum, but empirical evidence supporting the relationship between the two is still limited, but examining the predictive value of creative thinking (divergent and convergent thinking) for scientific reasoning, while considering task specificity and academic achievement, various aspects of divergent thinking (i.e. fluency, flexibility, and originality) benefit from different types of support. Students' fluency scores increased under the full support condition, but decreased in the other two conditions, the FI group had lower and more efficient cognitive load than the FD group. The effect of information load on cognitive load follows a piecewise linear correlation with two prominent nodes, field dependence-independence (FDI) can affect academic performance, selective attention, and working memory. However, the underlying mechanisms of how FDI modulates selective attention and working memory remain unclear, field independence (FDI) may affect academic performance, selective attention, and working memory. However, the underlying mechanism of how FDI modulates selective attention and working memory remains unclear and field-independent students produced better learning achievement but field-dependent students showed higher frustration tolerance, low-ability students experienced more significant improvement than high-ability students. Low ability students also showed higher frustration tolerance.

Keywords: Creative Mathematical Thinking, Cognitive Style, Field Dependent (FD), and Field Independent (FI)

Abstrak

Tujuan dari artikel ini menjelaskan perbedaan gaya kognitif siswa dan hasil berpikir kreatif matematis. Penelitian ini menggunakan metode Sistematic Literatur Review (SLR). Semua artikel yang berkaitan dengan berpikir kreatif matematika dan gaya kognitif dalam prestasi belajar siswa dicatat dan diteliti untuk mengumpulkan data. Sebanyak lima jurnal internasional yang digunakan hanya berfokus pada jurnal internasional terindeks dalam Scopus. Berbagai aspek pemikiran divergen (yaitu fleksibilitas, kelancaran, dan orisinalitas) mendapat manfaat dari berbagai jenis dukungan ketika mengkaji nilai prediktif pemikiran kreatif (berpikir divergen dan konvergen) untuk penalaran ilmiah, dengan tetap mempertimbangkan kekhususan tugas dan prestasi akademik, hasil penelitian menunjukkan bahwa berpikir kreatif dapat memperkuat kurikulum sains. Namun, ada sedikit bukti empiris yang mendukung hubungan antara keduanya. Nilai kefasihan siswa meningkat dalam kondisi dukungan penuh, tetapi menurun dalam dua kelompok lainnya. Ketergantungan-kemandirian lapangan (FDI) dapat mempengaruhi kinerja akademik, perhatian selektif, dan memori kerja; pengaruh beban informasi terhadap beban kognitif ditunjukkan oleh korelasi linier sepotong-sepotong dengan dua simpul yang menonjol. Namun, mekanisme yang mendasari bagaimana FDI memodulasi perhatian selektif dan memori kerja masih belum jelas. Kemandirian lapangan (FDI) dapat mengurangi beban kognitif dan lebih efisien daripada kelompok FD. kerja masih belum jelas, dan siswa yang mandiri di lapangan menghasilkan prestasi belajar yang lebih baik, tetapi siswa yang bergantung di lapangan menunjukkan toleransi yang lebih tinggi terhadap frustrasi, siswa yang berkemampuan rendah mengalami peningkatan yang lebih besar dibandingkan siswa yang berkemampuan tinggi, dan siswa yang berkemampuan rendah juga menunjukkan toleransi yang lebih besar terhadap frustrasi.

Kata Kunci: Berpikir Kreatif Matematis, Gaya Kognitif, Field Dependent (FD), Field Independent (FI)

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INTRODUCTION

Many researchers assume that people are creative, but the levels of creativity vary ((Kaufman & Beghetto, 2009); (Craft, 2003) One person's ability to develop concepts, technologies, or knowledge, while another person can merely use or accept it, serves as evidence of this. Combining logic and divergent thinking with an intentional objective, mathematical creative thinking is intuitively grounded. The mathematical creative thinking perspective describes an intuitive process that combines divergent and logical thinking with intentional aims. The concept of creativity is multifaceted, with different scholars examining it from different angles. ((Sriraman, 2005); (Mann, 2006)). A transition from a static perspective of creativity as an immutable personal trait to a dynamic one, seeing creativity as a signpost of personal growth, characterizes contemporary educational approaches. An understanding of the importance of creativity in math classrooms has resulted from this tendency. (Bolden et al., 2010) and how crucial it is for every learner to cultivate their creativity. Today, it is crucial to foster creativity in general and mathematical creativity in particular. This is because adapting to novel and difficult circumstances is vital for people's personal growth and serves as a fundamental mechanism for the advancement of society, technology, and science. ((Leikin & Pitta-Pantazi, 2013). believes that creative thinking is a useful synthesis of divergent and convergent thinking. From an operational perspective, this perspective yields a definition of creativity that is predicated on four interconnected elements: fuency, flexibility, novelty, and elaboration. One of the learning objectives of divergent thinking is creativity, which entails applying several approaches, coming up with novel and unusual ideas, and locating alternative answers and interpretations. Convergent thinking, however, depends heavily on knowledge as a source of ideas, a route to answers, and a standard for originality and efficacy. (Elgrably & Leikin, 2021) so that you can cultivate innovative conduct, optimistic attitudes, and exceptional character by honing your creative thinking abilities.

However, in reality, students' creative thinking abilities in Indonesia are still relatively low. This condition is shown by the Program for International Student Assessment (PISA) under the Organization for Economic Cooperation and Development (OECD) Class VIII students in Indonesia scored 64th out of 65 in a 2012 study on their maths proficiency. PISA questions were broken down into three domains and six levels, with level 6 being the most difficult. This situation is brought on by the achievement level of correctly answering questions at levels 5 or 6, which is extremely low—0.3%—and nearly nonexistent. from the average the proportion of international students—12.6%. Nonetheless, according to OECD PISA 2012, Indonesian students performed well (75.7%) when it came to accurately answering problems at levels 2 and 1. In general, questions concerning problems at levels 1 and 2 include analyzing the scenario presented in the problem and then applying general formulas to solve it in a methodical manner. This indicates that Indonesian students have not been able to acquire creativity or high-level thinking abilities (HOT), and instead have a tendency to only have low-level thinking abilities (LOT) that are procedural in nature. Algebraic content presents one

of the difficulties for pupils in cultivating creative thinking. Algebraic creativity requires proficiency with techniques linked to working with comparable In high school algebra, algebraic forms like the simplification of symbolic forms are typically viewed as computational tasks requiring the knowledge of numerous cognitive abilities. (Meguro, 2020). This is consistent with the viewpoint. assert that it is critical that all teachers and students cultivate their creativity, but there is evidence to support the claim that creativity is a fundamental mechanism that underpins the creation of new information, which is why creativity is seen as so vital to child development. 1930s/84s Vygotsky. In order to solve difficulties, pupils need to be able to control their affective abilities in addition to their cognitive abilities. In order to solve difficulties, students need to possess emotional skills such as self-efficacy, cognitive style, and learning motivation.

Cognitive style is a difference in cognitive activity, thinking, and remembering that will have an indirect and direct impact on an individual's actions and behavior. According to Jones and Wright (2012), cognitive style is a personal preference and ingrained method of arranging and presenting data. Consequently, cognitive style refers to an individual's way of thinking that incorporates cognitive abilities related to how they take in, store, process, and present information. This way of thinking will be highly consistent throughout an individual's life and will have an impact on both their behavior and activities. either directly or indirectly. (Ehrman et al., 2003) claims that while evaluating learning accomplishment, cognitive style has gotten the most focus in accounting education research.As stated by (Almolhodaei, 2002) cognitive style dimensions consist of Field Independent (FI) and Field Dependents (FD). (Hong et al., 2012) Field Dependent possesses a number of traits, such as: (1) a propensity for global thinking; (2) a tendency to accept the status quo due to a lack of ability to restructure; (3) a social orientation that makes them appear wise, kind, compassionate, and full of love toward others; (4) a tendency to choose careers that emphasize social skills; (5) a tendency to follow established goals; (6) a tendency to prioritize external motivation and are more interested in receiving praise, gifts, or other forms of external reinforcement from other people. The Field Independent dimension is typically predominant and tends to be independent, competitive, and self-assured.Demonstrate how student and teacher conduct distinguishes field dependent and field independent subjects.Cognitive styles that represent an individual's analytical approach to engaging with their surroundings are field independence (FI) and field dependence (FD). When faced with a situation, people with the FD cognitive style have a tendency to view things globally and are more impacted by their surroundings. Conversely, those with the FI cognitive style are less reliant on their surroundings and have a tendency to analyze patterns more analytically. They can also differentiate objects from their surroundings.

This issue in accordance with the viewpoint According to Borromeo, a student's unique method of processing information and the predominance of brain use will allow them to describe different thinking strategies to overcome problems with the best solutions, make decisions, and conceptualize them. Cognitive style, or being a visual and analytical thinker, influences learning

style tendencies. Under ideal circumstances, pupils will consider the optimal course of action, even going so far as to identify other students' thought processes based on variations in their cognitive styles when developing mathematical concepts.

Given the foregoing context, researchers are motivated to review the literature on students' creative mathematical thinking in relation to the distinctions between field dependent (FD) and field independent (FI) cognitive styles. It is envisaged that the findings of this literature review would be crucial for academics to delve deeper into the differences between Field Dependent (FD) and Field Independent (FI) cognitive styles, particularly Learning Achievement, in order to better understand students' innovative mathematical thinking. In this study, the problem is formulated as The research question, which is formulated in light of the problem's background, is: To what extent do students' learning achievements change depending on their cognitive styles and capacity for creative mathematical thought?

METHOD

This study use the Systematic Literature Review (SLR) method in conjunction with qualitative research methods. SLR is a research approach that begins with the identification, assessment, and interpretation of all pertinent research and is applied to specific research questions, themes, or phenomena that are under investigation. The SLR approach is employed in this kind of qualitative research to synthesis, or summarize, descriptive qualitative research findings. "Meta-synthesis" is the term for the process of synthesizing (summarizing) the findings of qualitative research; meta-synthesis is a strategy for integrating data to obtain new theories or concepts or deeper understanding (Kitchenham et al., 2010) There are various steps to this research, the first of which is developing research topics. This approach is used methodically, adhering to steps and protocols in order to prevent subjectivity and bias. In order to solve problems, students must be able to generate new and useful ideas by combining pre-existing elements. This research aims to measure students' mathematical creative thinking based on pertinent sources. Additionally, it seeks to determine the degree to which students' FI and FD cognitive styles differ when applying their learning achievements. Consequently, the study is titled Mathematical Creative Thinking and Variations in Students' Cognitive Styles in Utilizing Learning Achievements with the intention of identifying variations in students' cognitive styles and capacities for creative thought. The thorough approach is by looking up papers in the literature on the indexed by Scopus at the web https://www.sciencedirect.com/ using the specific keywords "Creative Thinking and Cognitive Learning Styles" to find pertinent journals. There are two categories of criteria used in sample selection: inclusion and exclusion. The sample criteria that the researcher wants depending on the goals of the study are the inclusion criteria. The inclusion criteria utilized in literature searches include studies pertaining to mathematical concepts, whereas the exclusion criteria are unique requirements that result in potential responders who satisfy the inclusion criteria being excluded from

the study group. linked to employing algebraic techniques to help pupils solve arithmetic problems in international periodicals. respectable according to Scopus quartile indexes 1–2, 3–4, and 4. In order to gather, choose, and evaluate the literature based on inclusion and exclusion criteria, researchers must improve the quality of their critical research studies and compile a systematic review before critically evaluating articles from primary and secondary research. Recording the papers is the next step for the researcher. Next, the researcher thoroughly reads through each paper, paying particular attention to the section on research results. Researchers compare and draw conclusions from their findings at the end of the study.

RESULT AND DISCUSSIONS

Data was collected through Scopus indexed international journals on the web https://www.sciencedirect.com/. The initial stage involved searching for articles using the Publish or Perish application, with the target of searching for 200 articles from 2023. In the search process, 100 articles were identified that discussed creative mathematical thinking. Of this number, 100 articles were also selected for review. Can be seen in the following VOS Viewer:

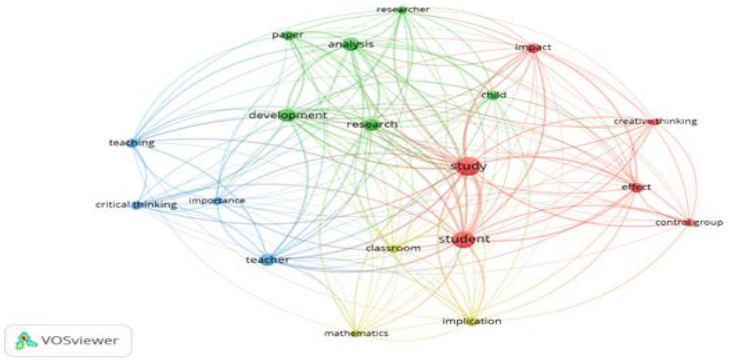

Figure 1. Search results for international articles indexed by Scopus at https://www.sciencedirect.com/

so that 2 articles were selected that met the criteria and were relevant to the aim of this research, namely how creative thinking in mathematics is related as follows:

Figure 2. Search results for international articles most related to creative mathematical thinking

Likewise in the aspect of cognitive style, from 200 articles from 2009-2003, 50 articles were identified for review. More details can be seen in the following image

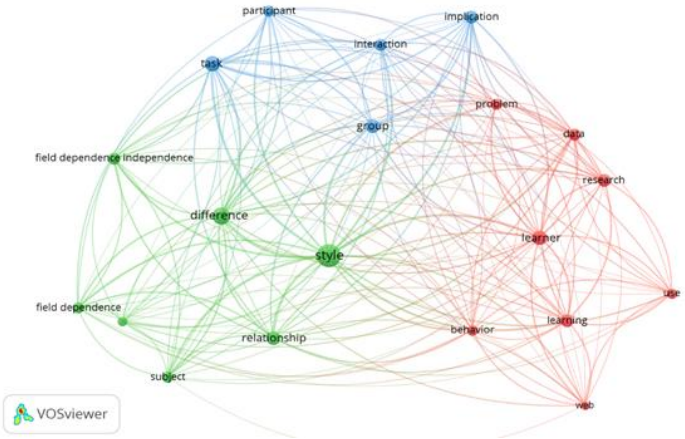

Figure 3. Search results for international articles indexed by Scopus at https://www.sciencedirect.com/

Finally 4 articles were selected that met the criteria and were relevant to the aim of this research, namely how the relationship between students' cognitive styles is as follows:

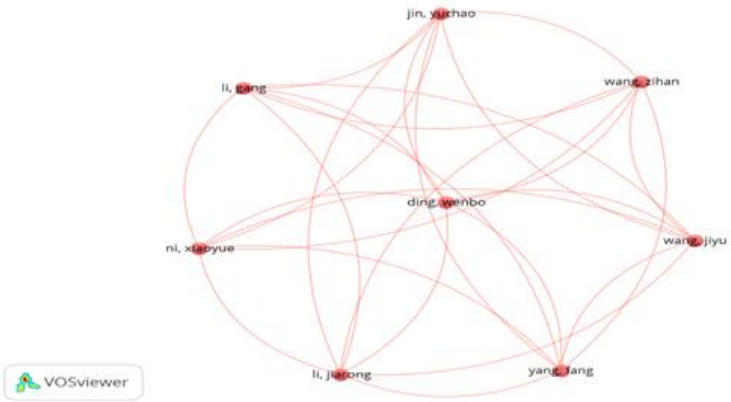

Figure 4. Search results for international articles that are most related to students' cognitive styles

Article selection is carried out by ensuring that each research contained in the article is in line with the focus of the research to be carried out. The research findings are developed further in a comprehensive discussion of this research. Next After selecting relevant articles, the next step involves analysis and in-depth study of the content of each article. Relevant data from each article is processed and analyzed to identify research descriptions of students' creative thinking abilities and cognitive styles using algebraic procedures. This research will focus on relevant data from 2 creative thinking literatures and 3 cognitive style literatures. The 2 articles most closely related to creative mathematical thinking are:

1. (Willemsen et al., 2023) In conclusion, theories suggest that scientific curricula should emphasize creative thinking, although there is currently little empirical data to support this claim. Taking

task specificity and academic accomplishment into consideration, this study is among the first to investigate the predictive utility of creative thinking (divergent and convergent thinking) for scientific reasoning. The development of research topics and the assessment of the evidence were favorably predicted by both verbal and visual convergent thinking, according to a path analysis based on data from 225 fifth graders. However, visual Research question construction was adversely predicted by divergent thinking. While reading comprehension positively predicted verbal convergent thinking, the formulation of research questions, and the assessment of the evidence, mathematical aptitude revealed to have no predictive value for any of the measures of creative thinking or scientific reasoning. The present study demonstrates the potential significance of convergent thinking for children's scientific reasoning. It can also be utilized as a springboard for further investigation into the function of creative thinking in scientific reasoning.

2. (Van Hooijdonk et al., 2023) determine that The purpose of this intervention study was to determine how geometry education can foster creative thinking. Five mathematics lessons using divergent and convergent thinking were given to fifth graders. Children were divided into three conditions: no support for creative thinking (n = 60), partial support for divergent thinking (n = 55), or complete support for both divergent and convergent thinking (n = 59). A multiple-choice test was used to evaluate divergent thinking, and scores were given for originality, fluency, and flexibility. Convergent reasoning was evaluated by an assessment of a concept task. Repeated actions MANOVA demonstrated that various forms of assistance were beneficial for many facets of divergent thinking, such as fluency, flexibility, and creativity. In the full support condition, students' fluency scores increased; in the other two circumstances, they fell. For inventiveness and flexibility, a contrasting pattern was observed, with a decline raised under the other conditions but maintained in the full support scenario. Convergent thinking did not exhibit any impacts of time or condition. Geometry scores increased, but not much, in any of the scenarios. Nonetheless, there were differences in geometry performance between the conditions; the full support condition had inferior geometry performance (both pretest and posttest) than the no support and partial support conditions. These findings offer some preliminary proof that teaching geometry can encourage divergent thinking. Conversely, it might be more challenging to successfully encourage convergent thinking. Teachers should think about tailoring support to the particular work at hand or the needs of each individual student, since various forms of help appear to influence different parts of divergent thinking.

The 3 articles most closely related to students' cognitive styles are:

3. (Ke et al., 2023) conclusion that construction project managers could make better decisions if they had access to a well-designed, visually appealing dashboard that provided them with clear information. Nevertheless, there hasn't been much research done on how dashboard information load affects cognitive load. Additionally disregarded were the user's cognitive style roles. This study looked at how user cognitive style and dashboard information load affected cognitive

burden when utilizing dashboards in the construction sector. Five information load levels were included in the visual search experiment that we created. 56 participants total, split between field-independent (FI) and field-dependent (FD) groups took part in the investigation. The findings demonstrated that compared to the FD group, the FI group was more productive and had a reduced cognitive load. With respect to the two significant knots, there was a piecewise linear association between the effect of information load and cognitive load. The results highlight how crucial it is to evaluate the amount of information available and offer psychological support for the building of a cognitive-fit dashboard in order to facilitate smart construction management.

4. (Li et al., 2016) conclusion that field dependence-independence (FDI) has been shown in the past to have an impact on working memory, selective attention, and academic performance. It is yet unknown, therefore, how FDI affects working memory and selective attention at the fundamental level. The current study demonstrated that for field independence (FI) participants, the correct response rates and CDA amplitudes in the 2-item and 2-item–2-distractor conditions were comparable using event-related potential (ERP) methodologies, specifically with the contralateral delay activity (CDA). Participants in field dependence (FD) performed poorer, and the presence of distractions increased the CDA amplitude. showed up. These findings suggested that FI participants are better than FD participants at sorting out information that isn't relevant to the job at hand. Individuals classified as FD or FI differ mostly in their inhibitory function..
5. (Ling & Salvendy, 2009) determine that The purpose of this study is to examine the effects of cognitive styles and past ability levels on learning achievement and frustration tolerance in an interactive group videogame called "Multiple-Choice Practice Island." The distinctions between pupils who were field dependent and those who were field independent were examined in terms of cognitive styles. The findings indicate that whereas field dependent students exhibit a higher level of frustration tolerance, field independent students have better learning outcomes. Furthermore, compared to high-ability pupils, low-ability kids improved noticeably more. In this study, low-ability pupils also show a better tolerance for frustration. The results can help developers create group-based videogames that are flexible and meet the demands of different players.

An individual with creative thinking skills can approach an issue from many angles, which helps him come up with original solutions. In order to be considered creative thinkers, students must be able to:

1. The Fluent Thinking component, where students are encouraged to pose numerous questions If there are any queries, respond with many responses. Possess numerous ideas regarding an issue, With ease articulating their thoughts, Work more quickly and efficiently than others, able to identify flaws and shortcomings in a situation or thing fast;
2. Flexible Thinking (Flexibility), in which pupils imagine a number of novel applications for an object, offer several interpretations of a picture, tale, or issue, apply a concept or principle in

numerous contexts, and take into account circumstances that differ from those described by others, Always take a stance that differs from the majority of the group while debating or discussing a situation. Usually, when faced with an issue, one can come up with multiple solutions. Sort items into groups based on distinct divisions (categories). able to impromptu alter one's line of thought;

3. Elaborative thinking (Elaboration), in which students use certain methods to look for deeper significance in responses or solutions to challenges, Expand upon or improve the ideas of others, To determine the course that details will take, try or test them. possess a keen sense of beauty and are not content with a bland or uninteresting appearance, incorporating details (sections) and lines from his own or other people's drawings.
4. Original thinking (Originality): students can consider issues or ideas that others haven't considered, challenge conventional wisdom and attempt to come up with fresh ideas, select asymmetry when describing or creating designs, select distinct ways of thinking from others, and search for fresh perspectives free of clichés. Work to complete new concepts after reading or hearing them; synthesize rather than analyze. (Craft, 2003).
5. Mentality Field independence (FI) and field dependence (FD) are two examples of cognitive styles that show how analytically an individual interacts with their surroundings. When faced with a situation, people with the FD cognitive style have a tendency to view things globally and are more impacted by their surroundings. Conversely, those with the FI cognitive style are less reliant on their surroundings and have a tendency to analyze patterns more analytically. They can also differentiate objects from their surroundings. Although people with an FD cognitive style and those with a FI cognitive style differ from one another, it is impossible to declare one cognitive type to be better than the other because each has pros and cons of its own. (Wang, 2017).

CONCLUSION

From a few of the evaluated articles, the following conclusions were reached in light of the findings and discussion: 1) Although there is still a lack of actual data to demonstrate a link between scientific and creative thinking, science curricula should encourage more creative thinking. One of the first studies to look at the predictive utility of creative thinking (both divergent and convergent thinking) for scientific reasoning while accounting for academic achievement and task specificity was this one. 2) An idea appraisal task was used to gauge convergent thinking. Different components of divergent thinking, such as fluency, adaptability, and creativity, benefited from different sorts of support, according to a repeated measures MANOVA. Fluency ratings among students increased in the

reduced in the other two circumstances, but increased in the full support condition. Flexibility and originality showed the opposite pattern, declining in the full support condition and increasing in

the other conditions; 3) This study looked at how user cognitive style and dashboard information load affected cognitive load when using dashboards in the construction industry. Five information load levels were included in the visual search experiment that we created. 56 individuals took part in the study, split into groups that were field-dependent (FD) and field-independent (FI) Try something. The findings demonstrated that compared to the FD group, the FI group was more productive and had a reduced cognitive load. With regard to the two prominent knots, the relationship between information load and cognitive load was piecewise linear; 4) study has shown how field dependence and independence (FDI) might impact working memory, selective attention, and academic achievement. It is yet unknown, therefore, how FDI affects working memory and selective attention at the fundamental level. With the use of contralateral delay activity (CDA) and event-related potential (ERP) methodologies, the current study discovered that the correct response rates and CDA amplitudes in the 2-item and 2-item–2-distractor conditions were similar for field

individuals with independence (FI); 5) The distinctions between pupils who were field dependent and those who were field independent were examined in terms of cognitive styles. The findings indicate that whereas field dependent students exhibit a higher level of frustration tolerance, field independent students have better learning outcomes. Furthermore, compared to high-ability pupils, low-ability kids improved noticeably more. In this study, low-ability pupils also show a better tolerance for frustration. The results can help developers create group-based videogames that are flexible and meet the demands of different players. Hence, despite the paucity of research on the subject, creative thinking abilities and variations in field Dependent (FD) and Field Independent (FI) cognitive styles are very intriguing for additional examination. Novelties also exist in (FD) and Field Independent (FI), particularly in algebraic solution techniques.

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