26 (4), 2025, 2720-2741

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

https://jpmipa.fkip.unila.ac.id/index.php/jpmipa

ULTRA: A Digital Gamification Approach to Boosting Mathematical Creative Thinking and Self-Regulated Learning

Dian Nopitasari*, Yaya Sukjaya Kusumah, Dadang Juandi, & Bambang Avip Priatna

Department of Mathematics Education, Universitas Pendidikan Indonesia, Indonesia

Abstract: The Mathematics Education Game is a gamification-based teaching material specifically designed to develop mathematical creative thinking skills and self-regulated learningin high school students. This game adopts a Snakes and Ladders format, consisting of three learning modules covering core trigonometry: basic concepts, quadrants, special angles, trigonometric equations, trigonometric identities, double-angle identities, sums and differences of angles, and multiplication of trigonometric functions. The game developed in this study, Attractive Trigonometric Snakes and Ladders (ULTRA), aims to serve as an engaging digital learning resource for students in grades XI and XII. The purpose of this study is to examine the improvement in creative thinking skills and self-regulated learning of students who use ULTRA. The research method uses the ADDIE model and is evaluated through three research instruments: (1) a mathematical creative thinking test containing four essay questions to measure fluency, flexibility, originality, and elaboration; (2) a 24-item self-regulated learning questionnaire that assesses goal setting, monitoring, strategy use, and reflection; and (3) a 15-item student response questionnaire to assess usability and engagement. Effectiveness was analyzed using normalized gain, while validity and practicality were reviewed through expert assessment and descriptive data. The research subjects were 496 students from 16 classes, comprising 247 in the experimental class and 249 in the control class. This study concluded that ULTRA is valid, practical, and has potential as a digital medium for mathematics learning. Effectiveness testing conducted in four schools showed a moderate increase in N-Gain in mathematical creative thinking skills, as well as positive behavioral indicators of learning independence, indicating that ULTRA strengthens students' higher-order thinking skills and independence. Overall, the findings indicate that the ULTRA game has the potential to improve mathematical creative thinking and self-regulated learningwhile providing an engaging digital learning experience for students.

Keywords: education game, creative thinking, self-regulated learning.

▪ INTRODUCTION

In contemporary mathematics education, students still face persistent learning challenges, particularly in developing higher-order thinking skills such as creative reasoning, problem solving, and self-regulated learning. Despite curricular reforms, many mathematics classrooms remain dominated by teacher-centered instruction, procedural exercises, and limited opportunities for students to explore concepts meaningfully (Ibrahim et al., 2024). This condition results in students who struggle to think flexibly, connect mathematical ideas, and apply concepts to unfamiliar contexts—skills essential for success in the 21st century. Furthermore, the lack of engaging, interactive learning environments contributes to decreased motivation and lower student participation, ultimately hindering the formation of a learning community capable of adapting to technological and societal developments (Subekti, 2022). According to the 2022 PISA survey, Indonesia was ranked 12th from the bottom in mathematics rankings (OECD Publishing, 2023). This suggests that 15-year-old Indonesian students are unable to use

Dian Nopitasari
*Email: dian.nopitasari511@gmail.com

DOI: http://dx.doi.org/10.23960/jpmipa.v26i4.pp2720-2741
Received: 14 November 2025
Accepted: 12 December 2025
Published: 26 December 2025

their fundamental skills accurately or extract pertinent information from a single literary source.

Furthermore, daily learning outcomes in class regarding mathematical creative thinking skills remain suboptimal (Kurniasih et al., 2022; Saleh et al., 2022; Tabieh & Hamzeh, 2022). This tendency is also evident in recent Indonesian school-based studies: among Grade XI students at SMA Negeri 1 Enok, the average mathematical creative thinking score was only 29% overall, with elaboration at 13% and fluency and originality around 30% and 29%, which places students in the low category of creative thinking ability (Wardani & Suripah, 2023). Likewise, at SMP Negeri 1 Dungaliyo, the overall achievement in mathematical creative thinking on triangle material reached only 59.26%; of 27 students, only four were categorized as high, 16 as medium, and seven as low (Kadir et al., 2022). Students' independence in addressing challenges assigned by teachers remains insufficient, as they tend to rely solely on their more capable peers (Ellis & Helaire, 2018; Febriyanti & Imami, 2021; Rasheed et al., 2020).

These facts starkly contradict the demands of the 21st century, which require graduates to possess strong creative thinking skills and the ability to engage in self-regulated learning. However, some mathematics instruction still discourages students from developing these essential competencies, as classroom practices often emphasize routine procedures and predetermined solutions rather than exploration and independence (Fauzi et al., 2019; Ishartono et al., 2022). As a result, learning remains fixated on fundamental, theoretical, and impractical concepts that offer limited relevance to real-world problem-solving. To remain aligned with current and future societal needs, the focus of instructional activities must shift from content-driven delivery to approaches that nurture innovation, flexibility, and autonomous learning habits.

Beyond the rapidly evolving role of technology, improving the quality of human resources through education remains inseparable from the contributions of educators, both teachers and lecturers, who serve as key facilitators of effective learning (Dwi Putriani, 2021). Their pedagogical decisions significantly influence students' motivation, engagement, and learning outcomes. Therefore, a productive collaboration between educators and technology is essential to create a more engaging, student-centered learning environment. By integrating digital tools, interactive learning strategies, and continuous learning opportunities, students can maximize their educational experiences while developing the competencies needed to thrive in the 21st century (Joshi et al., 2023).

The development of digital technology in the last decade has brought about a significant transformation in the world of education. The integration of technology into the learning process, particularly through educational games, has been shown to increase student engagement, motivation, and learning effectiveness (Dan et al., 2024). Educational games utilize the principles of play as a learning tool, encouraging active participation and meaningful learning experiences through interaction, challenges, and direct feedback (Tokac et al., 2019). Educational games are interactive learning media that combine game elements with instructional objectives to enhance the learning experience (Jaccard et al., 2021). In the context of mathematics learning, the application of educational games is considered capable of overcoming negative perceptions of subjects that are often seen as complex and abstract (Gao et al., 2020). Educational games provide students with space to experiment with concepts, try various problem-solving

strategies, and receive direct feedback, all of which are essential for developing creative mathematical thinking.

Mathematical creative thinking skills include idea fluency, strategic flexibility, and originality in solving mathematical problems (Behnamnia et al., 2020). Learning that focuses on conventional procedures often fails to foster these abilities. In contrast, game-based learning environments encourage exploration and discovery, thereby strengthening students' creative dimensions in mathematical contexts. Educational games provide a learning environment that supports the emergence of creativity through exploratory activities and problem-solving (Putu et al., 2023). A study by Behnamnia et al. (2020) showed that children who learned using educational games showed significant improvements in creative thinking dimensions, particularly flexibility and originality. Similarly, research by Cámara-Martínez et al. (2023) found that learning mathematics through games can improve children's self-confidence and social skills, both of which support creative thinking. Through a game-based approach, students can view mathematical problems from various perspectives and develop divergent thinking skills (Akif Bircan & Cumhuriyet, 2022). Thus, educational games are not only a means of entertainment but also a vehicle for developing mathematical creativity that supports meaningful learning.

Furthermore, the implementation of educational games is closely linked to the development of self-regulated learning (SRL). In contemporary digital learning research, SRL is conceptualized not only as students' ability to plan, monitor, and evaluate their learning, but also as a dynamic process shaped by digital tools, feedback systems, and interactive environments (Panadero, 2017). Recent SRL models emphasize metacognitive regulation supported by technology-enhanced platforms, where features such as real-time feedback, adaptive challenges, and gamified reward structures promote strategic decision-making and self-reflection (Bembenutty, 2023). Educational games that integrate these elements have been shown to strengthen students' self-regulation by encouraging goal-setting, persistence, and iterative problem-solving (Jiang & Shangguan, 2022). Moreover, bibliometric analyses reveal that the intersection of SRL and educational games represents a growing interdisciplinary domain in digital education, driven by the shared emphasis on learner autonomy, engagement, and active participation (Zhang et al., 2020).

In addition to supporting independence, game design also fosters intrinsic motivation because game mechanics structured around the stages of self-regulated learning (planning, behavioral control, and reflection) can increase sustained learning motivation (Cheung & Ng, 2021). This aligns with research by Albayrak et al. (2022), which found that active, engaging math games can improve self-confidence, self-concept, and social interaction in early childhood, all of which are important foundations for self-regulated learning. In game-based learning models, students not only pursue scores or victory but also understand the thought processes used to achieve these outcomes (Matic et al., 2023). This makes games a learning environment that encourages learning by reflection.

Although various studies demonstrate the great potential of educational games to enhance creative thinking and self-regulated learning, several challenges remain to be addressed. Dan et al. (2024) conducted a systematic review and found that most existing studies were small-scale and short-term, and rarely examined the transferability of skills

to broader learning contexts. Therefore, research on the implementation of educational games in mathematics learning needs to be further developed, particularly in evaluating the extent to which games can simultaneously and sustainably enhance mathematical creative thinking and self-regulated learning. In this regard, the present study offers several forms of novelty that address these gaps. First, unlike many previous studies that focus on single learning aspects, the ULTRA game is specifically designed to target two higher-order competencies simultaneously: mathematical creative thinking and self-regulated learning through an integrated gamification structure. Second, ULTRA incorporates a unique combination of game elements (progressive leveling, thematic challenge cards, dynamic scoring, and a real-time leaderboard) that are explicitly mapped onto indicators of creative thinking and SRL, a level of pedagogical alignment that is often missing in earlier game-based interventions. Third, this study adopts a multi-school, multi-grade implementation involving more than 16 classes, which represents a considerably broader empirical context than prior small-scale trials, typically confined to a single school or one or two classrooms. Fourth, the evaluation not only measures pre- and post-achievement but also assesses normalized gain (N-Gain) and analyzes patterns of skill development across different school profiles, providing richer evidence on the effectiveness and transferability of the game. Taken together, these contributions position the ULTRA game as a more comprehensive, scalable, and pedagogically grounded approach compared to existing educational game studies, thereby offering an important advancement in the field of mathematics education technology.

▪ METHOD

Participants

The subjects of the ULTRA research and development were 11th- and 12th-grade students from SMAN 9, SMAN 10, SMA Muhammadiyah 3, and SMA Bina Insani. The study was conducted across 16 classes: 8 experimental and 8 control. The experimental class consisted of 247 students, and the control class of 249, for a total sample of 496. The research sample was selected using cluster random sampling. The students showed varying initial cognitive abilities, ranging from a basic introduction to trigonometry to requiring full assistance in trigonometric operations. Their previous experience with technology also varied, ranging from those using simple digital devices to those with little or no exposure. They generally needed clear visual instructions, repetition, and multimodal support in the learning process.

Research Design and Procedures

This research is a quantitative study employing a quasi-experimental design with a non-equivalent control group, using an experimental and a control class. The ULTRA game-based learning model was applied to the experimental class. Meanwhile, the control class applied the conventional learning model. Before giving treatment at the first meeting, students will take a pretest to measure initial ability. At the end of the learning process, students take a posttest to assess improvement in their initial ability.

Instrument

The data collection instruments in this study consisted of two main components. First, the validity of ULTRA in trigonometry material was assessed using two instruments: a media validity sheet, completed by media experts, with 10 items evaluating

design, navigation, interactivity, readability, and suitability for students, and a material validity sheet, completed by subject matter experts, with 10 items measuring content accuracy, curriculum alignment, systematic presentation, relevance to learning objectives, and difficulty level. Second, the effectiveness of ULTRA was evaluated through a student response questionnaire. The student questionnaire consisted of 15 items covering the appearance and design of the game, the speed of understanding and knowledge acquisition, and improvements in learning outcomes, especially in creative thinking skills and learning independence. Meanwhile, a creative thinking ability test and a self-regulated learning questionnaire were administered as pre-test and post-tests. Instrument testing was conducted using pre-test and post-tests, with creative thinking indicators listed in Table 1.

Table 1. Creative thinking skills instrument grid

Creative thinking indicators	Trigonometry material	Number of Questions
Fluency	Trigonometric ratios in a right triangle	1
Flexibility	rigonometric identities and the sine–cosine relationship	2
Originality	Right triangle and step-by-step explanation	3
Elaboration	Context-based trigonometry problems (angles of elevation and depression)	4

To objectively and systematically measure students' creative thinking skills, it is essential to use an assessment instrument with clearly defined, measurable criteria. In this study, a creative thinking assessment rubric was developed based on four key indicators: fluency, flexibility, originality, and elaboration. These indicators represent the core components of students' mathematical creative thinking abilities. Each indicator is evaluated on a four-level rating scale (1-4), with performance descriptors tailored to the characteristics of mathematical problem-solving tasks. This rubric is used to assess both the process and the outcomes of students' work in completing the open-ended tasks assigned during the study. The detailed descriptors of the creative thinking assessment rubric are presented in the following table.

Table 2. Mathematics creative thinking assessment rubric

Indicator	Score 4	Score 3	Score 2	Score 1
Fluency	Produces ≥ 4 correct and relevant solutions/strategies	Produces 3 correct and relevant solutions/strategies	Produces 2 correct and relevant solutions/strategies	Produces 1 or no correct solution
Flexibility	Uses ≥ 3 different methods/representations (diagrams, tables, algebra, graphs)	Uses 2 different methods / representations	Uses 1 method with limited variation	Uses 1 rigid and inappropriate method
Originality	Applies a unique and uncommon strategy rarely used by other students	Applies a fairly unique strategy, used by some students	Applies a common and routine strategy	Fully imitates the given example

Elaboration	Solution steps are complete, systematic, logical, and detailed	Solution steps are systematic and fairly detailed	Solution steps are incomplete and lack detail	Solution steps are unclear and illogical

The indicators in the self-regulated learning instrument used in this study, as referenced by Hidayati & Listyani (2010), were compiled into a questionnaire to measure students' level of self-regulated learningbefore the learning process or intervention. This questionnaire was compiled based on several self-regulated learning indicators in Table 3.

Table 3. Self-regulated learning instrument outline

Self-regulated learning indicators	**Statement**		**Total**
	Positive	**Negative**	
Assesses goal setting	1. 2. 3. 5. 6	4	6
Monitoring	7. 8. 9. 11	10. 12	6
Strategy use	14. 15. 16. 17. 18	13	6
Reflection	20. 21. 23. 24	19. 22	6
Total	18	6	24

The self-regulated learning instrument on the questionnaire sheet consists of positive questions (+) and negative questions (-) where the answer choice format is based on the Likert model scale which consists of 5 (five) alternative answer choices: Strongly Agree (SA), Agree (A), Less Agree (LA), Disagree (DA), Strongly Disagree (SDA) each answer will be given a score of 5, 4, 3, 2, and 1 for positive statements, while for negative questions with answer choices: Strongly Agree (SA), Agree (A), Less Agree (LA), Disagree (DA), Strongly Disagree (SDA) each answer will be given a score of 1, 2, 3, 4, and 5.

The research instruments, consisting of a creative thinking ability test and a self-regulated learning questionnaire, were first evaluated for content validity, criterion validity, and reliability. Based on the results of the expert validation involving three experts, all learning devices and research instruments were declared valid, as Aiken's V index values exceeded 0.4, which is the minimum validity threshold. In addition, the level of agreement among the experts was examined using Cohen's kappa coefficient, yielding $\kappa = 0.593$, indicating moderate inter-rater agreement.

Furthermore, the content validity indices for the self-regulated learning questionnaire and the creative thinking ability test were 0.824 and 0.817, respectively. Both values fall within the range of ≥ 0.8, which is categorized as high validity. Therefore, it can be concluded that the developed research instruments meet the established validity criteria and are suitable for use in the subsequent trial stage.

The construct validity of the instrument was examined using the Pearson Product-Moment correlation, which assesses the degree to which each item correlates with the total score of its respective construct. An item is considered valid when the obtained correlation coefficient exceeds the critical value at the 0.05 significance level, indicating that the item adequately measures the intended latent variable. Next, the validity of the creative thinking ability test items was analyzed using the Product-Moment correlation, yielding 4 valid items and 3 invalid items from a total of 64 participants. Similarly, the validity of the self-regulated learning questionnaire items was assessed using the same

procedure; of 40 statements, 24 were classified as valid and 16 as invalid. Following the establishment of item validity, a reliability analysis was conducted to assess the instrument's internal consistency before proceeding to further statistical analysis.

The reliability of the creative thinking ability test instrument was analyzed using Cronbach's Alpha, yielding a value of 0.834, indicating acceptable reliability. The reliability of the self-regulated learning questionnaire was assessed using Cronbach's Alpha, yielding a value of 0.863, which exceeds the recommended threshold of 0.70, indicating the questionnaire's reliability. Thus, the learning tools and research instruments used in this study were proven to be valid and reliable, making them suitable for use as measuring tools in research. The reliability test of the collaboration and science literacy instrument was conducted on 64 students. The test results were analyzed using the Cronbach's alpha formula in SPSS 21. The Cronbach's Alpha score is displayed in Table 4.

Table 4. Results of the cronbach-alpha score

Variable	Cronbach-Alpha	Item Total	Category
Creative Thinking	0.834	4	Reliable
Self-Regulated Learning	0.863	24	Reliable

Data Analysis

The data analysis in this study is divided into two parts: analysis of the instruments used and analysis of the data obtained (descriptive and inferential). To obtain participants for the implementation phase, a cluster sampling technique was employed. Four senior high schools, two public and two private, were selected to represent diverse academic environments and school profiles in the region. Within these schools, 16 intact classes from Grades XI and XII were chosen based on their availability and the teachers' willingness to implement the ULTRA game during mathematics lessons. This approach yielded a total of 496 students, ensuring a sufficiently large and heterogeneous sample to evaluate the game's validity, practicality, and effectiveness. Cluster sampling was chosen because intact classes could not be randomly rearranged due to school scheduling constraints, while still allowing the researcher to gather data from multiple natural classroom groups, thereby enhancing ecological validity and generalizability within similar educational contexts. To assess improvement before and after the use of educational games, the N-gain formula (Hake, 1998) is used; the results of the N-gain calculation are presented against several criteria in Table 5.

Table 5. N-Gain criteria

No.	N-gain Score	Criteria
1	$g > 0.7$	High
2	$0.3 \leq g \leq 0.7$	Medium
3	$g < 0.3$	Low

In addition to calculating the gain scores, students' self-regulated learning was further analyzed through a categorical classification to provide a clearer description of the distribution of students across different levels. The classification of self-regulated learning was conducted by converting the obtained scores into five categories in the following table.

Table 6. Score categorization

Score	Category
$0 - 20$	Very low
$21 - 40$	Low
$41 - 60$	Medium
$61 - 80$	High
$81 - 100$	Very high

After calculating the gain, the next step is to calculate the effect size. The effect size test is used to measure and classify the effects of a treatment (Borenstein et. al., 2009). The purpose of the effect size test in this study was to determine the magnitude of the effect of implementing the ULTRA game on students' creative thinking skills and self-regulated learning. Cohen (1988) established criteria based on the results of the effect size test: d = 0.2 is a small effect, d = 0.5 is a medium effect, and d = 0.8 is a large effect. Furthermore, Frohlich et al. (2009) stated that d < 0.10 is considered trivial or has no effect, d < 0.10 is considered small, d < 0.30 is considered medium, and d > 0.50 is considered large. Based on these two opinions, the authors classify effect sizes in the following table.

Table 7. Effect size criteria

Criteria	Clasification
$d > 0.50$	Large Effect
$0.30 < d \leq 0.50$	Medium Effect
$0.00 \leq d \leq 0.30$	Small Effect

The assessment is based on student feedback on the implementation of educational games in educational institutions. Student responses are classified according to the criteria outlined in Table 8.

Table 8. Student response criteria

No.	Percentage	Criteria
1	90% - 100%	Very Good
2	80% - 89%	Good
3	60% - 79%	Good Enough
4	0% - 59%	Not Good

▪ RESULT AND DISSCUSSION

Result

The instructional game created in this research is titled "Ular Tangga Trigonometri Atraktif (ULTRA)." This educational game was designed to enhance students' creative mathematical thinking abilities and self-regulated learning. ULTRA can be installed directly via a barcode on mobile devices (Android) and desktop computers (PC). This document provides a comprehensive overview of the development and implementation phases of ULTRA in high school mathematics education.

The primary task during the analysis phase is to perform a preliminary investigation, encompassing a field survey and a review of relevant literature. The field survey activities encompass data collection on the planning and observation of

mathematics instruction in high schools in Tangerang City, a needs assessment, identification of obstacles to learning, and synthesis of concerns related to mathematics creative thinking abilities and student autonomy in education. This activity produces a mapping of the study's variables, the formulation of indicators for these variables, and the development of measurement instruments, accompanied by evaluation rubrics, including validation sheets, observation sheets, test instruments, and questionnaires. After conducting preliminary studies and surveys of schools, the next step was to create a design for ULTRA. Below is a hypothetical design for the ULTRA game.

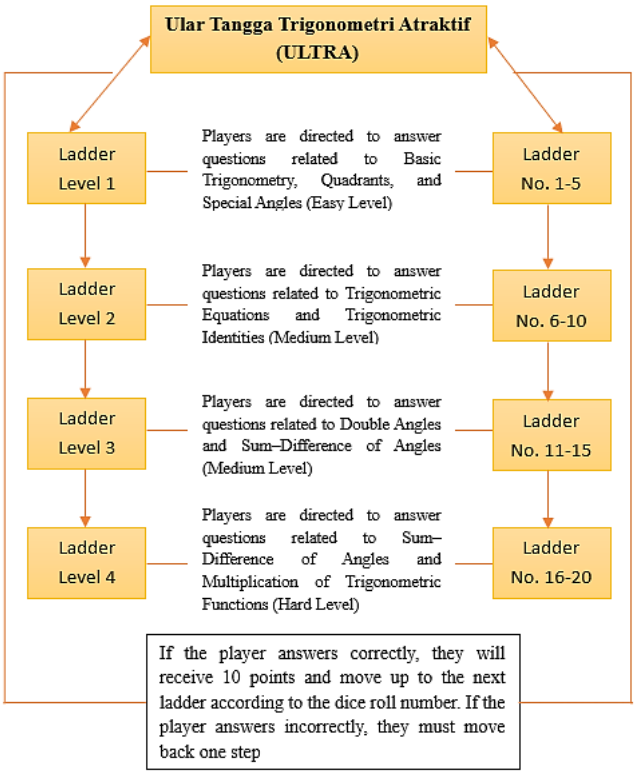

Figure 1. Hypothetical design of ULTRA

ULTRA is an interactive mathematics learning game for high school students, presented as a snakes-and-ladders game with multiple-choice questions across three levels: easy, medium, and difficult. Before starting the Snakes and Ladders game, users can review a summary of trigonometry. The material covers basic trigonometry concepts, quadrants, special angles, trigonometric equations, trigonometric identities, double-angle identities, sums and differences of angles, and multiplication of trigonometric functions. Players are asked to solve problems that match the indicators of creative thinking, ranging from easy to medium to challenging levels. In addition, the Snakes and Ladders game requires users to develop self-regulated learning skills. Players can answer the existing questions with the choices given according to the number of dice obtained. If the player's answer is correct, they will get 10 points; if the player answers incorrectly, points will not be reduced, but the player must move back 1 step. This game also features a hint menu. This game can be played in pairs on multiple platforms, namely mobile and desktop. This

game also involves two characters who faithfully accompany the player. The ULTRA board game display design is presented in Figure 2.

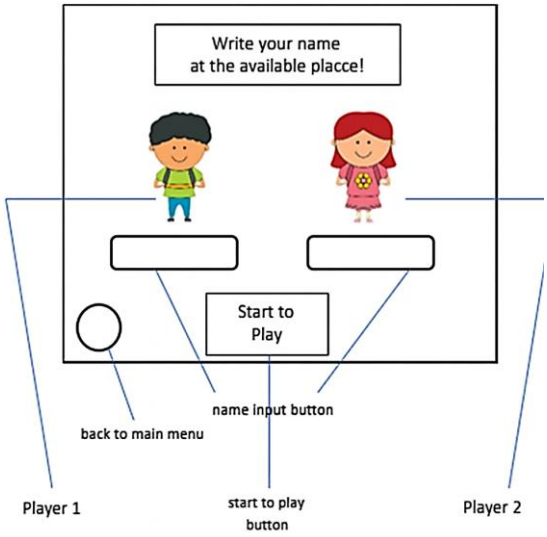

Figure 2. Initial design of ULTRA display

The gameplay is similar to that of a Snakes and Ladders game played in pairs. Players take turns rolling the dice and moving according to the number shown on each square containing multiple-choice questions. A correct answer earns 10 points and allows players to climb the ladder. A wrong answer earns them 1 square back, or they descend to the snake's tail. The player who reaches the final square first is declared the winner.

After creating the ULTRA design, the next step was to develop ULTRA into an educational game using Adobe Flash CS3 software to create an interactive digital game. The ULTRA display is shown in Figure 3.

Figure 3. ULTRA view

After the ULTRA game was developed, the next step was to test its validity and reliability. The ULTRA game content was validated and found to be reliable by a team of experts, including education and ICT experts.

After the validation testing phase, the ULTRA game was ready to be implemented in a relevant environment. The ULTRA game was implemented in three high schools in Tangerang City with 496 research subjects. The implementation was carried out in grades XI and XI I (Phase F). A series of product trial activities in each class was conducted across five meetings, including a pretest, three meetings on ULTRA use, and a posttest. The duration of each meeting was 3 JP (3 x 45 minutes).

Figure 4. Implementation of ULTRA game in schools

The ULTRA effectiveness test results on students' creative thinking abilities were analyzed using a paired 2-sample t-test at a 5% significance level and an N-Gain test. To complement these statistical measures, a scatter plot with regression lines for each participating school was constructed to visually depict the relationship between pre-test and post-test scores. As shown in the scatter plot, all schools demonstrate a consistent positive trend: higher pre-test scores correspond with higher post-test outcomes, reinforcing the statistical evidence of improvement. The upward trajectories of the regression lines indicate that students experienced measurable gains in creative thinking skills following the ULTRA intervention, with variations in slope across schools reflecting differences in the magnitude of improvement. This visual pattern aligns with the t-test and N-Gain findings, collectively confirming that ULTRA had a significant and positive impact on students' creative thinking performance. The complete results of this analysis are illustrated in Figure 5.

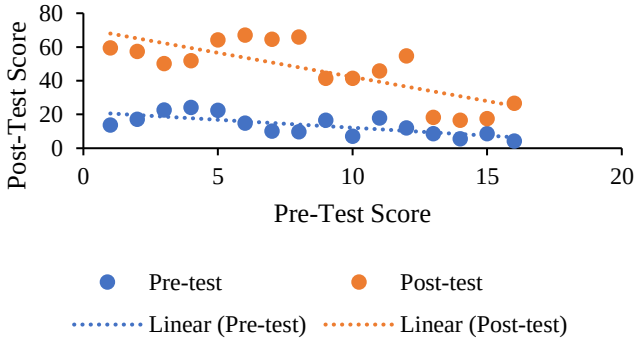

Figure 5. Scatter plot of pre-test post-test scores by school

Based on Figure 6, the scatter plot of pre-test and post-test scores across the four participating schools shows a consistent positive association between students' initial competencies and subsequent learning outcomes following the implementation of the ULTRA game. Distinct regression lines for each school reveal clear upward trends, indicating that higher pre-test scores correspond with higher post-test results. This relationship suggests that baseline proficiency remains an important predictor of learning achievement, even when instructional innovations such as gamification are integrated. Overall, the data indicate that the ULTRA intervention improved students' mathematical performance across diverse educational settings.

Based on the N-Gain analysis, there was a significant difference in the increase in creative thinking ability scores between the experimental and control classes. The experimental class obtained a higher N-Gain score (0.36), considered moderate, while the control class obtained a lower N-Gain score (0.23), considered low. The detailed N-Gain scores for each indicator of creative thinking ability are presented in Figure 6.

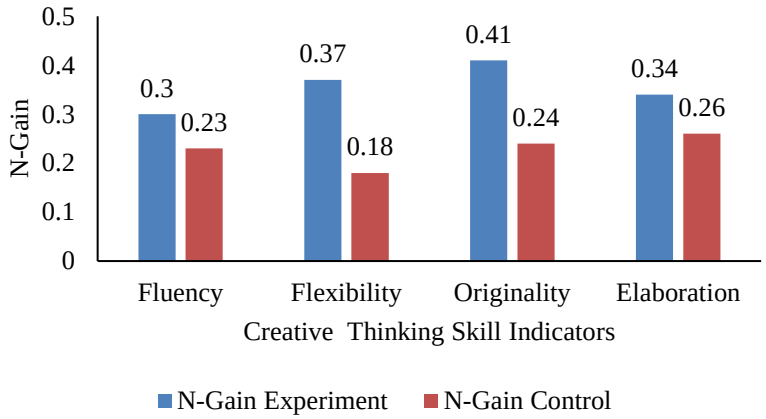

Figure 6. N-Gain analysis by the indicator of students' creative thinking skills

Figure 6 shows that the N-Gain scores of the experimental group are consistently higher than those of the control group across all indicators of creative thinking skills: fluency, flexibility, originality, and elaboration. On the fluency indicator, the experimental group achieved an N-Gain of 0.30. In contrast, the control group obtained 0.23, indicating a greater improvement in students' ability to generate ideas in the experimental class. A more pronounced difference is observed in flexibility, where the experimental group reached an N-Gain of 0.37, compared to only 0.18 in the control group, suggesting that the ability to apply diverse problem-solving strategies developed more optimally under the experimental treatment. The originality indicator shows the highest N-Gain in the experimental group at 0.41. In contrast, the control group recorded 0.24, indicating a substantial improvement in students' ability to produce unique, original solutions. Meanwhile, for elaboration, the experimental group attained an N-Gain of 0.34, slightly higher than the control group's 0.26, indicating better improvement in students' ability to elaborate and refine ideas. Overall, these results confirm that the instructional intervention applied in the experimental class has greater potential to improve students' creative thinking skills than the conventional learning approach used in the control class. Quantitatively, this effect size is comparable to that reported by Zheng (2019), who found

a moderate effect (g = 0.48) of goal-oriented gamified tasks on creative thinking. However, the ULTRA results demonstrate a slightly higher upper-range effect than that reported by Ratnawati et al. (2020), whose creative-thinking intervention produced an N-Gain of 0.36 in secondary mathematics settings.

To obtain a more detailed representation of students' self-regulated learning profiles, the distribution of each self-regulated learning indicator was further visualized using a 100% stacked bar chart. By presenting the data in relative percentages, the diagram allows for clearer comparison of the structural patterns of self-regulated learning across groups. It highlights shifts in students' regulatory behaviors across different performance levels. The comparative visualization of these distributions is presented in Figure 7.

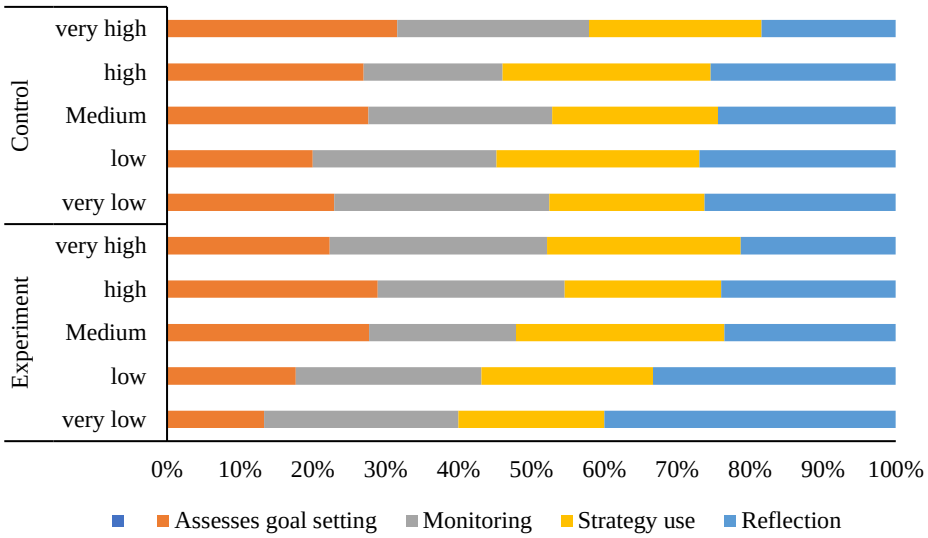

Figure 7. Diagram 100% stacked bar self-regulated learning

Figure 7 indicates that the experimental group demonstrated a substantial shift toward the medium, high, and very high categories across all four self-regulated learning indicators. In contrast, the control group remained predominantly in the low and medium categories. This suggests that the intervention effectively supported the development of students' SRL processes, particularly in goal setting and monitoring, which are critical to sustained self-directed learning. These findings are consistent with recent SRL research, which highlights that structured instructional approaches that incorporate explicit metacognitive prompts, strategic guidance, and reflective activities can significantly enhance learners' capacity to regulate their own learning (Panadero, 2017; Dent & Koenka, 2016). The observed improvement in strategic behavior and reflection among students in the experimental group also aligns with the framework proposed by de Bruin and van Gog (2015), who emphasize the importance of continuous monitoring and adaptive strategy use in strengthening metacognitive control. Moreover, the more balanced component structure evident in the experimental group's SRL profile mirrors the integrated regulatory cycle described by Panadero & Alonso-Tapia (2014), indicating that students not only improved quantitatively but also experienced qualitative

development in the coordination of planning, monitoring, strategy implementation, and reflection. Taken together, these findings reinforce the view that pedagogical designs emphasizing structured SRL support can lead to meaningful gains in both the level and coherence of students' self-regulated learning processes.

To assess the magnitude of the treatment effect, Cohen's d was used to calculate the effect size. Effect size analysis provides information beyond statistical significance, demonstrating the practical impact of the ULTRA game on learning. The results of the effect size analysis for each measured variable are presented in the following Figure.

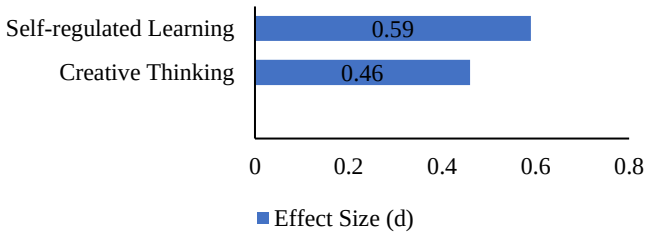

Figure 8. Effect size test result

Figure 8 presents the results of the effect size analysis for the two measured variables, namely creative thinking and self-regulated learning. The effect size for creative thinking is 0.46, which falls into the medium effect category, indicating that the implemented learning intervention had a moderate impact on students' creative thinking skills. Meanwhile, the effect size for self-regulated learning is 0.59, which is classified as a large effect, suggesting that the intervention had a strong and meaningful influence on students' self-regulated learning. These findings demonstrate that the learning intervention was particularly effective in enhancing students' independence in learning and in improving their creative thinking. In contrast, studies such as Bunt and Gouws (2020) showed smaller effect sizes (Cohen's d = 0.32) for gamification on self-regulation, suggesting that the ULTRA design, particularly its incorporation of progressive goals and real-time leaderboard feedback, may offer a stronger motivational structure than simpler gamification formats. Creating a gamification application based on goal-setting theory necessitates progress indicators, several challenges, accomplishment levels, various feedback mechanisms, and a competitive element (Kalogiannakis et al., 2021).

In addition to assessing students' creative thinking skills and self-regulated learning, ULTRA's effectiveness was also assessed based on student responses. Three student response indicators were measured: responses to the game's appearance and design, responses to students' speed of comprehension and knowledge enhancement, and responses to perceived improvements in learning outcomes, particularly in creative thinking and self-regulated learning. A summary of student responses is presented in Table 9 below.

Table 9. Student response results

Criteria	Average Response Score	%	Category
Look and Design of the Game	4.20	84%	Very good

Velocity of Comprehension and Acquisition of Knowledge	4.11	82%	Very good
Enhancement of educational achievements	3.98	80%	Good
Average (496 students)	4.10	82%	Very good

Based on Table 9, 82% of students across all schools reported using ULTRA in mathematics learning and rated it as very good. According to all students, the game's appearance and design were rated very good, the speed of comprehension and knowledge acquisition was also rated very good, and the improvement in learning outcomes, particularly in creative thinking and self-regulated learning, was rated good. The enhancement of these two skills was further facilitated by the game's sophisticated features and its clear objective. The game was designed with a hierarchical structure that progresses from easy to challenging and features questions specifically aligned with signs of creative thinking. Furthermore, the game's features utilize attractive illustrations tailored to the characteristics of high school students, thereby enhancing student independence in learning the material. This is consistent with numerous studies showing that goal-setting theory is closely associated with gamification, as clear and attainable goals tend to enhance learners' motivation and engagement. However, rather than merely aligning with previous work, this study's findings enable a more critical comparison of effect magnitudes.

These differences in effect size may indicate that the alignment between game mechanics and learning indicators plays a critical role in determining impact. ULTRA's structured progression system and explicit goal-setting prompts likely enhance learners' strategic focus and provide clearer performance expectations, yielding a stronger motivational response than gamification models that rely solely on badges or points. Nevertheless, the variability observed across classes in this study (with N-Gain ranging from 0.18 to 0.71) highlights that the effect is not uniform and may depend on contextual factors such as teacher facilitation, school culture, and initial student readiness. This nuanced pattern underscores that while goal-setting theory provides a foundational explanation, the actual effect of gamification is mediated by classroom conditions and the tightness of alignment between goals, feedback, and cognitive demand.

Based on interviews with students, three main themes emerged: the game's appearance and design; responses to students' speed of understanding and knowledge enhancement; and responses to perceived improvements in student learning outcomes, particularly in creative thinking skills and student self-regulated learning. A description of the three main themes found is presented in the following table.

Table 10. Student interview results

Student	ULTRA Game Appearance	Speed of Understanding & Knowledge Enhancement	Improvement in Learning Outcomes (Creative Thinking & Self-regulated Learning)
Student 1	The game's appearance is attractive, with bright colors, a clear game	Understands trigonometric ratios faster because the questions are presented	Becomes more independent in learning and more creative in

	board, and characters that make it feel lively and not boring.	gradually; gains knowledge about real-life applications of trigonometry.	trying various problem-solving strategies.
Student 2	The design is unique and distinct from typical learning media; combining Snakes and Ladders with trigonometry problems increases learning motivation.	Understanding improves more quickly because each move requires thinking; gains deeper knowledge of sine, cosine, and tangent formulas.	Becomes more independent without always relying on the teacher and is more willing to try new solution strategies.
Student 3	The appearance is enjoyable with animations and easy-to-understand symbols, making the student stay focused and not easily bored.	Trigonometry understanding improves faster with immediate feedback; gains a better understanding of the relationship between angles and sides in triangles.	Creative thinking improves through level-up strategies and independence in managing study time.
Student 4	The visual display is attractive and balances game and learning elements, creating a relaxed learning atmosphere.	Grasps concepts more quickly due to active thinking; trigonometry knowledge expands through repeated practice.	Becomes accustomed to solving problems independently and is more creative in finding alternative answers.
Student 5	The design is interesting and not boring, motivating continuous play and learning.	Understands the material more quickly because learning feels relaxed; knowledge increases through varied practice questions.	Becomes more independent, confident, and creative in solving trigonometry problems.

Based on interviews with five students, the findings indicate that the ULTRA game has an attractive visual appearance, characterized by contrasting colors, a clear game board design, and supportive characters and animations that create an engaging learning atmosphere. In terms of understanding, students reported that the presentation of trigonometry material through interactive gameplay with gradually increasing problem levels and immediate feedback enabled them to comprehend concepts more quickly and enhance their knowledge, both in mastering formulas and in applying trigonometry to real-life contexts. Furthermore, the use of the ULTRA game had a positive impact on learning outcomes, particularly in students' creative thinking skills, as reflected in their willingness to explore various problem-solving strategies, and in their self-regulated learning, as evidenced by their ability to study autonomously, increased self-confidence, and reduced dependence on teacher guidance.

The findings of this study provide several important theoretical and practical implications. Theoretically, the results strengthen existing literature on gamification by demonstrating that well-designed game elements, such as leaderboards, levels, scoring systems, and structured rules, can significantly enhance students' creative thinking skills and self-regulated learning. This contributes to refining gamification theory by

highlighting the dual impact of competitive features. While they can substantially increase motivation and metacognitive engagement, they may also trigger anxiety among lower-performing students. The study also reinforces contemporary frameworks of mathematical creativity, showing that challenge-based and interactive learning environments can support the development of fluency, flexibility, and originality.

Practically, the findings suggest several directions for improving instructional design and classroom implementation. Teachers are encouraged to integrate game-based learning strategies, such as ULTRA, to create engaging and student-centered activities that foster deeper cognitive and self-regulatory skills. However, careful classroom management is essential to prevent potential negative effects such as unhealthy competition or excessive dependence on game mechanics. The technical limitations identified, such as system instability, inconsistent scoring, lack of iOS compatibility, and limited media display, highlight the need for developers to enhance platform reliability, accessibility, and cross-device usability. Furthermore, schools may consider adopting adaptive leaderboard features, such as anonymous ranking or tier-based grouping, to ensure that competitive elements remain motivating rather than discouraging. Finally, the study underscores the necessity for future research to examine personality traits, gender differences, and risks of overuse to ensure that gamification tools are inclusive, equitable, and effective for diverse learner profiles.

The integration of leaderboard functionality into ULTRA creates a competitive learning environment that increases student motivation and engagement. The leaderboard enables students to compare their performance with that of their peers, thereby enhancing their awareness of learning progress and encouraging goal-oriented behavior. Such mechanisms often foster healthy competition, stimulate persistence, and promote greater effort as learners strive for higher rankings. Frequent leaderboard updates further intensify the competitive atmosphere, motivating students to continually improve their performance. Indirectly, this environment cultivates key 21st-century competencies, particularly creative thinking and self-regulated learning, as students engage in metacognitive monitoring, strategize to improve their scores, and reflect on their learning processes. However, existing literature warns that the motivational effects of leaderboards are not universally positive. Schlömmer et al. (2021) highlight that leaderboard transparency can produce feelings of inadequacy among students positioned at the bottom, potentially increasing anxiety and disengagement. This indicates that while leaderboards enhance motivation for some learners, they may simultaneously reduce confidence and participation for others, necessitating careful consideration in their implementation.

Beyond competitive elements, ULTRA demonstrates strong validity across game components, instructional alignment, and design coherence. The inclusion of structured rules, character representations, leveling systems, scoring mechanics, and problem sets tailored to the development of mathematical creative thinking skills reflects adherence to the core principles of gamification-based learning design. These elements align closely with Kelle et al. (2011), who argue that effective gamification emerges from learner-centered design processes. According to their framework, instructional design should begin with an analysis of learners' needs and intended outcomes, followed by iterative refinement and integration of game elements such as logic, rules, narrative, levels, scoring, and feedback loops. ULTRA's design successfully incorporates these principles,

illustrating how game mechanics can be harmonized with educational objectives to create meaningful learning experiences. The clarity and coherence of the game structure contribute to its ability to scaffold problem-solving, stimulate creativity, and support cognitive development through engaging tasks.

The effectiveness analysis revealed a significant medium increase in students' mathematical creative thinking skills and learning autonomy. These findings align with a growing body of research demonstrating that gamification can enhance creative thinking and self-regulated learning. Zheng (2019) emphasizes that gamified environments stimulate divergent thinking, encourage risk-taking, and sustain engagement, three essential components of creativity. Similarly, Ratnawati et al. (2020) reported substantial improvements in creativity indicators such as fluency, flexibility, and originality when students engaged with game-based learning activities. Bunt & Gouws (2020) further found that gamification increases student autonomy by enabling personalized learning pathways and self-paced exploration. Despite these strengths, several technical limitations were identified in ULTRA. System instability, including unexpected crashes, disrupts learning continuity and may frustrate learners. Inaccuracies in scoringparticularly the automatic awarding of points for repeated correct answers, may compromise the validity of progress assessment. Limited device compatibility, especially the absence of support for iOS, restricts accessibility. Additionally, the image display sizes on certain devices make some problem statements difficult to interpret, highlighting the need for adjustable zooming. Addressing these issues is vital for optimizing usability and maximizing learning outcomes.

Despite the promising outcomes of gamification in educational contexts, certain challenges must be acknowledged. Teachers play a critical role in regulating classroom behavior within gamified frameworks to mitigate risks such as over-engagement, gaming addiction, and reduced academic focus (Zheng, 2019). Moreover, gamification does not affect all learners equally. Smiderle et al. (2020) found that personality traitsparticularly introversion and extroversion, moderate students' engagement and outcomes in gamified learning environments. Introverted students were more likely to exhibit sustained engagement and improved academic performance than their extroverted peers. This represents a limitation of the present study, which did not examine the potential negative effects of ULTRA nor account for gender differences, personality traits, or the risks of overuse. Therefore, future studies should explore these moderating variables to gain a comprehensive understanding of ULTRA's pedagogical impact and to ensure inclusive and equitable game design.

The findings indicate that ULTRA has the potential to enhance students' mathematical creative thinking and self-regulated learning through its combination of competitive elements, structured game mechanics, and learner-centered design. While the leaderboard fosters motivation and engagement, its effects vary across learners, emphasizing the need for careful implementation. ULTRA's game components demonstrate high validity and strong alignment with pedagogical goals, resulting in meaningful improvements in cognitive and metacognitive skills. However, several technical limitations, such as system instability, scoring inaccuracies, limited compatibility, and visual display issues, must be addressed to optimize the platform. Moreover, the study reveals that gamification does not affect all learners equally, with personality traits serving as important moderating factors. Overall, ULTRA demonstrates

substantial potential as an innovative educational tool, though further refinements and expanded research are necessary to ensure inclusivity, usability, and long-term effectiveness.

▪ CONCLUSION

The results of the ULTRA potential test on mathematical creative thinking abilities, self-regulated learning, and student responses from 496 students across four schools indicate that ULTRA has the potential to enhance high school students' mathematical creative thinking skills and self-regulated learning, achieving a medium-level increase. However, despite the observed improvement in students' mathematical creative thinking skills and self-regulated learning, these competencies remain within the medium category. Therefore, further investigation is required to identify the causal factors and their corresponding solutions to optimize the potential of the ULTRA game to foster students' mathematical creative thinking and self-regulated learning to a high level. This study is limited to trigonometry and focuses exclusively on students' mathematical creative thinking skills and learning autonomy. Consequently, further research is needed to examine the potential improvement of these two competencies across various subject areas and to investigate the internal and external factors influencing their development, thereby ensuring consistency and optimal learning outcomes. Moreover, the current version of ULTRA is a two-dimensional application with limited functionality, particularly in generating descriptive questions or short-response items. Therefore, future development should upgrade the application to a three-dimensional environment to make it more engaging and challenging in mission completion. In addition, it is essential to incorporate features that enable the assessment of students' responses in descriptive formats.

▪ REFERENCES

Akif Bircan, M., & Cumhuriyet, S. (2022). An investigation of classroom teachers' educational digital game Designs for mathematics teaching and their opinions on the design process. In *International Journal of Curriculum and Instruction* (Vol. 14, Issue 3). https://orcid.org/

Albayrak, M., Simsek, M., & Yazici, N. (2022). The Effect of Educational Games on Success in Teaching Mathematics: Reading and Writing Natural Numbers. *International Journal on Social and Education Sciences*, *4*(4). https://doi.org/10.46328/ijonses.460

Behnamnia, N., Kamsin, A., Ismail, M. A. B., & Hayati, A. (2020). The effective components of creativity in digital game-based learning among young children: A case study. *Children and Youth Services Review*, *116*. https://doi.org/10.1016/j.childyouth.2020.105227

Bembenutty, H. (2023). Self-regulated learning with computer-based learning environments. *New Directions for Teaching and Learning*, *2023*(174). https://doi.org/10.1002/tl.20543

Branch, R. M. (2010). Instructional design: The ADDIE approach. In *Instructional Design: The ADDIE Approach*. https://doi.org/10.1007/978-0-387-09506-6

Bunt, B., & Gouws, G. (2020). Using an artificial life simulation to enhance reflective critical thinking among student teachers. In *Smart Learning Environments* (Vol. 7,

Issue 1). https://doi.org/10.1186/s40561-020-00119-6

Cahyadi, R. A. H. (2019). *Pengembangan Bahan Ajar Berbasis Addie Model* [Development of Teaching Materials Based on the Addie Model]. *Halaqa: Islamic Education Journal*, *3*(1). https://doi.org/10.21070/halaqa.v3i1.2124

Cámara-Martínez, A., Ruiz-Ariza, A., Suárez-Manzano, S., Cruz-Cantero, R. M., & Martínez-López, E. J. (2023). Effect of an integrated active lessons programme through playful maths games on self-concept, self-esteem, and social skills in preschool children. *Behavioral Sciences*, *13*(3). https://doi.org/10.3390/bs13030260

Cheung, S. Y., & Ng, K. Y. (2021). Application of the educational game to enhance student learning. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.623793

Dan, N. N., Trung, L. T. B. T., Nga, N. T., & Dung, T. M. (2024). Digital game-based learning in mathematics education at primary school level: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(4). https://doi.org/10.29333/ejmste/14377

Dwi Putriani, J. (2021). *Penerapan pendidikan indonesia di era revolusi industri 4.0* [implementation of indonesian education in the era of the industrial revolution 4.0]. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(3).

Ellis, J. M., & Helaire, L. J. (2018). The effects of adolescent self-regulated learning on engagement in a college access program: an exploratory study. *AERA Open*. https://doi.org/10.1177/2332858418756051

Farida, F., Khoirunnisa, Y., & Putra, R. W. Y. (2018). *Pengembangan bahan ajar gamifikasi pada materi bangun ruang sisi lengkung* [development of gamification teaching materials on curved side space building materials]. *Jurnal Penelitian Dan Pembelajaran Matematika*, *11*(2). https://doi.org/10.30870/jppm.v11i2.3765

Fauzi, K. M. A., Dirgeyase, I. W., & Priyatno, A. (2019). Building learning path of mathematical creative thinking of junior students on geometry topics by implementing metacognitive approach. *International Education Studies*, *12*(2). https://doi.org/10.5539/ies.v12n2p57

Febriyanti, F., & Imami, A. I. (2021). *Analisis self-regulated learning dalam pembelajaran matematika pada siswa smp* [analysis of self-regulated learning in mathematics learning for junior high school students]. *Jurnal Ilmiah Soulmath : Jurnal Edukasi Pendidikan Matematika*, *9*(1). https://doi.org/10.25139/smj.v9i1.3300

Gao, F., Li, L., & Sun, Y. (2020). A systematic review of mobile game-based learning in STEM education. *Educational Technology Research and Development*, *68*(4). https://doi.org/10.1007/s11423-020-09787-0

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1). https://doi.org/10.1119/1.18809

Hidayati, K., & Listyani, E. (2010). *Pengembangan instrumen kemandirian belajar siswa* [Development of student learning independence instruments]. Jurnal Pendidikan Matematika, 1(1), 1–10

Ibrahim, Khalil, I. A., & Indra Prahmana, R. C. (2024). Mathematics learning orientation: Mathematical creative thinking ability or creative disposition? *Journal on*

Mathematics Education, *15*(1). https://doi.org/10.22342/jme.v15i1.pp253-276

Ishartono, N., Nurcahyo, A., Waluyo, M., Prayitno, H. J., & Hanifah, M. (2022). Integrating GeoGebra into the flipped learning approach to improve students' self-regulated learning during the COVID-19 pandemic. *Journal on Mathematics Education*, *13*(1). https://doi.org/10.22342/jme.v13i1.pp69-86

Jaccard, D., Suppan, L., Sanchez, E., Huguenin, A., & Laurent, M. (2021). The co.lab generic framework for collaborative design of serious games: Development study. *JMIR Serious Games*, *9*(3). https://doi.org/10.2196/28674

Jiang, F., & Shangguan, D. (2022). Researching and designing educational games on the basis of "self-regulated learning theory." *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.996403

Joshi, D. R., Adhikari, K. P., Khanal, J., Belbase, S., & Khanal, B. (2023). Developing and integrating digital resources in online mathematics instruction and assessment during COVID-19. *Cogent Education*, *10*(2). https://doi.org/10.1080/2331186X.2023.2230394

Jusuf, H. (2016). *Penggunaan gamifikasi dalam proses pembelajaran*. *Jurnal TICOM*, *5*(1).

Kadir, I. A., Machmud, T., Usman, K., & Katili, N. (2022). *Analisis kemampuan berpikir kreatif matematis siswa pada materi segitiga. Jambura Journal of Mathematics Education*, *3*(2), 128–138. https://doi.org/10.34312/jmathedu.v3i2.16388

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. I. (2021). Gamification in science education. A systematic review of the literature. *Education Sciences*, *11*(1). https://doi.org/10.3390/educsci11010022

Kelle, S., Klemke, R., Gruber, M., & Specht, M. (2011). Standardization of game based learning design. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *6785 LNCS*(PART 4). https://doi.org/10.1007/978-3-642-21898-9_43

Kurniasih, A. W., Purwanto, Hidayanto, E., & Subanji. (2022). Teachers' skills for attending, interpreting, and responding to students' mathematical creative thinking. *Mathematics Teaching-Research Journal*, *14*(2).

Matic, L. J., Karavakou, M., & Grizioti, M. (2023). Is Digital game-based learning possible in mathematics classrooms? *International Journal of Game-Based Learning*, *13*(1). https://doi.org/10.4018/ijgbl.323445

OECD Publishing. (2023). *PISA 2022 results (volume i): the state of learning and equity in education*. OECD Publishing. https://doi.org/https://doi.org/10.1787/53f23881-en

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. In *Frontiers in Psychology* (Vol. 8, Issue APR). https://doi.org/10.3389/fpsyg.2017.00422

Pujakusuma, G. A., & Dkk, . (2018). Game incredible math berbasis android sebagai media pembelajaran virtual reality. *Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika (SNMPM)*, *2*(1).

Putu, I., Putra, A. S., & Paramita, V. A. (2023). The use of digital educational games as learning media: a study on elementary school teachers. *International Journal of Elementary Education*, *7*(2).

Rasheed, R. A., Kamsin, A., Abdullah, N. A., Kakudi, H. A., Ali, A. S., Musa, A. S., &

Yahaya, A. S. (2020). Self-regulated learning in flipped classrooms: A systematic literature review. *International Journal of Information and Education Technology*, *10*(11). https://doi.org/10.18178/ijiet.2020.10.11.1469

Ratnawati, N., Sukamto, Ruja, I. N., & Wahyuningtyas, N. (2020). "Defense of the ancients", gamification in learning: Improvement of student's social skills. *International Journal of Emerging Technologies in Learning*, *15*(7). https://doi.org/10.3991/IJET.V15I07.13221

Rosly, R. M., & Khalid, F. (2017). *Gamifikasi: Konsep dan implikasi dalam pendidikan* [Gamification: Concepts and implications in 21st Century Learning education]. *Pembelajaran Abad ke-21: Trend Integrasi Teknologi*, *144*(154), 1903-1910.

Saleh, H., Nopitasari, D., Fadillah, A., & Bilda, W. (2022). Analysis of students' creative thinking skills in linear algebra courses during the covid-19 pandemic. *Prima: Jurnal Pendidikan Matematika*, *6*(1). https://doi.org/10.31000/prima.v6i1.5266

Schlömmer, M., Spieß, T., & Schlögl, S. (2021). Leaderboard positions and stress experimental investigations into an element of gamification. *Sustainability (Switzerland)*, *13*(12). https://doi.org/10.3390/su13126608

Smiderle, R., Rigo, S. J., Marques, L. B., Peçanha de Miranda Coelho, J. A., & Jaques, P. A. (2020). The impact of gamification on students' learning, engagement, and behavior based on their personality traits. *Smart Learning Environments*, *7*(1). https://doi.org/10.1186/s40561-019-0098-x

Subekti, F. Y. (2022). *Pengembangan media video pembelajaran materi persamaan linear satu variabel dengan kinemaster pro* [development of learning video media for one variable linear equations material with kinemaster pro]. *Jurnal Penelitian Sains Dan Pendidikan (JPSP)*, *2*(1). https://doi.org/10.23971/jpsp.v2i1.3448

Tabieh, A. A. S., & Hamzeh, M. (2022). The impact of blended-flipped learnthe impact of blended-flipped learning on mathematical creative thinking skills. *Journal of Educators Online*, *19*(3). https://doi.org/10.9743/JEO.2022.19.3.15

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning*, *35*(3). https://doi.org/10.1111/jcal.12347

Wardani, Y. E., & Suripah, S. (2023). *Kemampuan berpikir kreatif matematis siswa sma berdasarkan kemampuan akademik* [high school students' mathematical creative thinking ability based on academic ability]. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *7*(3). https://doi.org/10.31004/cendekia.v7i3.2338

Zhang, R., Cheng, G., & Chen, X. (2020). Game-based self-regulated language learning: Theoretical analysis and bibliometrics. *PLoS ONE*, *15*(12). https://doi.org/10.1371/journal.pone.0243827

Zheng, Y. (2019). 3D course teaching based on educational game development theory - Case study of game design course. *International Journal of Emerging Technologies in Learning*, *14*(2). https://doi.org/10.3991/ijet.v14i02.9985