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Si-GEMAS: Serious game mathematical crossword puzzle learning media for students critical thinking ability

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Abstract

Possessing a discerning mindset is a vital aptitude required to thrive in the fiercely competitive environment of the 21st-century global society. Given that nurturing critical thinking is an integral component of human existence, it is incumbent upon us to innovate and refine the methods by which we foster such essential cognitive skills in students. Among these innovations, one noteworthy development is the inception of the Si-GEMAS crossword puzzle learning medium. The focal point of this study was the creation and validation of the Si-GEMAS tool to bolster mathematical critical thinking skills among eighth-grade students at YALCP Pasuruan. This resource was intended to be a valid, practical, and effective learning aid in terms of both validity and efficiency.The study adopted the Borg and Gall developmental model as its primary methodological framework. The research sample consisted of ten students from the eighth grade. The tools employed to gather data included validation checklists, questionnaires assessing the responses of teachers and students, as well as assessments to evaluate the students' learning outcomes.The findings indicated that the Si-GEMAS learning medium scored exceptionally well regarding its relevance to the students' critical thinking skills, thereby demonstrating its validity and efficiency. The results pointed to an improvement in students' critical thinking skills, with average scores rising from 65.67 to 88.28, constituting a substantial increment of 22.61. Therefore, it becomes clear that the Si-GEMAS medium can serve as a potent tool to assist students in cultivating their critical thinking skills throughout the learning process.

INTRODUCTION

Quality education is a crucial pillar of the 21st century, particularly with the ongoing advancement of science and technology in the era of 5.0 (Fukuda, 2020; Inganah et al., 2023). Given the rapid pace of change in the world today, it is essential that education perpetually adapts and evolves. Elevating the quality of education mandates teachers to adopt inventive pedagogical methods and media, designed to hone students' abilities. Utilizing such innovative approaches can augment the effectiveness of teaching and learning processes, resulting in improved student performance (Darmayanti, Sugianto, Baiduri, et al., 2022). Consequently, prioritizing the implementation of such methodologies in educational institutions becomes instrumental in fostering a high-quality education.

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In the global society of today, critical thinking abilities are indispensable for both personal and professional growth. Higher-order thinking skills, along with critical thinking abilities, are some of the most valuable proficiencies schools can impart to students (Arisoy & Aybek, 2021; Meirbekov et al., 2022). These skills equip individuals to navigate intricate situations and make enlightened decisions, traits paramount in today's competitive scenario. Hence, integrating critical thinking education into the curriculum is crucial in preparing students to tackle real-world challenges. It is pertinent to innovate and investigate new teaching methodologies for critical thinking, aiming to cultivate intellectual growth in students. By laying stress on the development of critical thinking skills, we can nurture a generation of individuals prepared to confront 21st-century challenges with conviction and aptitude.

Low levels of student engagement and interest in the learning process are significant issues that demand attention. Prior research indicates that a lack of variation in pedagogical methods, along with insufficient student involvement, can lead to diminished student interest in learning (Perini et al., 2018). To mitigate these issues, this study proposes the use of 'serious games' as a learning medium. Such games can spark student interest and amplify their involvement in the learning process. The choice of serious games rests on their potential to make learning more engaging and their flexibility, encouraging more active student participation (Moloney et al., 2017). Consequently, serious games are expected to enhance student outcomes and stimulate critical thinking, thus promoting the humanistic elements of learning.

A serious game, essentially a learning medium, is a potential problem-solving tool (Chen & Hsu, 2020; Iten & Petko, 2016). It can function as a software simulation designed to bolster learning outcomes (Girard et al., 2013). Serious games activate student participation in teaching and learning processes and can facilitate direct interaction (Loh, 2009; Ullah et al., 2022). They can offer an authentic, repeatable experience, allowing learners to correct their mistakes (Perini et al., 2018). Such games can ignite critical thinking in students, a hallmark of which is the emergence of humanistic aspects in education – a shift from the mere acquisition of knowledge towards value-based learning.

Unfortunately, many educators refrain from utilizing learning resources, and scarce media facilities contribute to waning interest in learning and developing critical thinking skills (Alpusari et al., 2020; Güner & Erbay, 2021; Nugroho et al., 2018). Initial observations during pre-mathematics learning at the Assyfa Learning Center (YALC) Pasuruan Foundation revealed that instructors frequently employed the lecture method and media that engaged students were seldom used. Proactive questioning and critical thinking to solve problems requiring alternative solutions should not only be encouraged but should also be a fun part of the learning process (Morozova et al., 2022; Siburian et al., 2019). Traditional teaching approaches often render students passive and limit their thinking. Therefore, educators must offer ample opportunities for students to actively hone their skills (Haftador et al., 2021). Impeding students from expressing their thoughts can hinder the development of their critical thinking abilities.

For educators to effectively foster students' critical thinking abilities, they must have access to engaging teaching materials that incorporate the use of learning media. As an integral tool, learning media is highly regarded for its capacity to facilitate the learning

process. The utilization of learning media is essential in attaining educational objectives and serving as a beneficial aid for both teachers and students (McAdoo et al., 2019; Oracion & Abina, 2021). Such media can harmonize students' understanding of course material, thereby maximizing learning outcomes (Rachmavita, 2020). Furthermore, when appropriately deployed in a classroom setting, learning media can assist students in transforming abstract mathematical concepts into concrete realities. This fosters increased motivation and enthusiasm towards mathematics learning (Alphonce & Mwantimwa, 2019; Hasanah, Syaifuddin, et al., 2022; Song & Bonk, 2016). Moreover, well-structured mathematical games, often seen as mere pastime activities, can actually stimulate intellectual development, foster critical thinking, enhance problem-solving abilities, and deepen students' understanding of mathematical procedures.

The manner in which students engage with mathematics can significantly impact their comprehension of diverse concepts within the discipline. The entertaining aspect of games can motivate students, fostering a deeper understanding of these concepts (Cardinot et al., 2022; Danilovic & de Voogt, 2021; Scott et al., 2023). One such example of media used specifically for mathematical education is the crossword puzzle. These mathematical crosswords offer an alternative method that maximizes student potential, fostering a more active and creative engagement with mathematics. They stimulate reasoning and knowledge acquisition, facilitate comprehension, enhance motivation and enjoyment, and provide memorable learning experiences (Wati & Suhardi, 2022). When properly implemented, numerical crossword puzzles can prove highly effective in improving students' academic performance and critical thinking abilities

Previous research underscores the positive impact of crossword puzzles on learning outcomes, student engagement, and critical thinking (Bar & Otterbring, 2021). Studies have revealed that crossword puzzles improve memory, performance, and critical thinking (Agarwal et al., 2020; Herawati, 2022). Furthermore, these puzzles, when used as a recreational tool, can enhance learning engagement and outcomes. Students' responses to crossword puzzles have been largely positive, indicating their effectiveness as a learning tool (Niculescu & Ștefănică, 2022).

The present study aims to advance the use of crossword learning media to develop the thinking skills of Grade VIII students, particularly in the domain of flat-sided geometric material (calculating the length of a side of a geometric shape given the lengths of the other sides, finding the area and volume of a geometric shape, and understanding the elements and fundamental concepts related to three-dimensional shapes). Questions will be presented in six progressive levels, catering to various indicators of critical thinking skills. The proposed media, dubbed "Si-GEMAS", aims to reinforce traditionally taught material through the utilization of Geometry Material Crossword Puzzles.

Furthermore, engaging with mathematical crossword puzzles, whose purpose is to evaluate the comprehension of learning material and provide a platform for repetition, can increase students' enthusiasm for the learning process. To complete these puzzles, students must master the material. Given these considerations, the goal of this study is to develop the Si-GEMAS learning media to enhance the mathematical critical thinking skills of Grade VIII SMP students at YALCP Pasuruan. This tool aims to be valid, practical, and effective in the learning process.

METHODS

This study employs a Research and Development (R&D) approach, leveraging the Borg & Gall procedure. The Borg & Gall process encompasses ten distinct development steps, culminating in a finished product ready for deployment: identifying needs and issues, collecting data, designing the product, validating the design, revising the design, testing the product, revising the product, conducting trial usage, modifying the product, and initiating mass production. However, given time and cost considerations, this research on Si-GEMAS media development is confined to seven steps, necessitating intensive face-to-face interactions, as depicted in Figure 1.

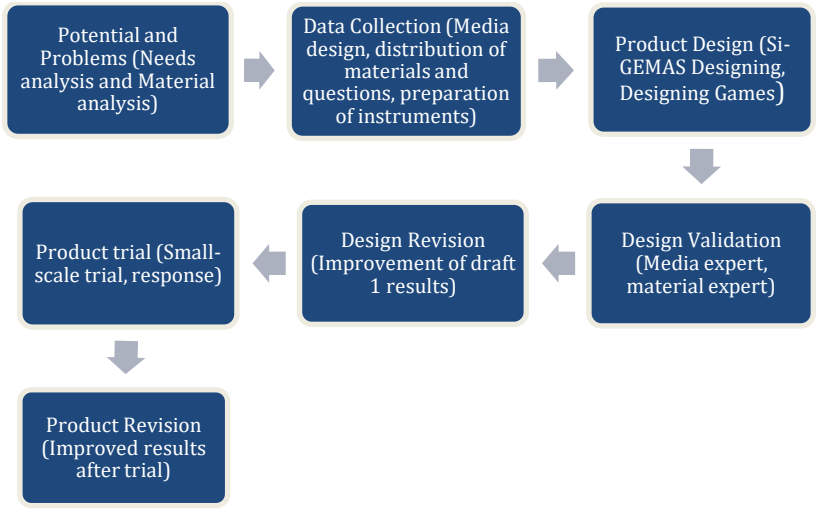

Figure 1. Stages of Borg and Gall Development Flow

Based on figure 1, to develop the Si-GEMAS crossword puzzle for studying geometric operations, the first step is a needs and material analysis. This identifies potential users and recognizes any gaps in existing materials that the puzzle could address. Following this, the researchers will create the media and distribution strategy, including the puzzle layout, vocabulary, and game mechanics. The designs will then undergo validation by media and material experts, with their feedback used to revise the design as necessary. Small-scale trials will be conducted to evaluate product efficacy and gather user feedback. Subsequent revisions will be made to the product based on these trial results, to enhance its effectiveness and usability.

The subjects of this study are Class VIII students at YALC Pasuruan. Product trials will involve media design experts and learning material specialists. Professional testing by these experts occurs in three stages. After this, a small-scale trial with ten randomly selected students is conducted. Data collection is facilitated through the use of questionnaires, which include a design expert questionnaire, a material expert questionnaire to ascertain product efficacy, and a student response questionnaire to determine product practicality.

Data analysis techniques employed are both qualitative and quantitative descriptive analysis. Qualitative descriptive analysis is undertaken by categorizing qualitative data, such as input, criticism, and suggestions for improvement derived from the questionnaires. This method is used to process data gathered from expert judgment in the form of suggestions and feedback to enhance the mathematics crossword game media. Quantitative descriptive

analysis involves analyzing numerical data collected from the questionnaires. The assessment criteria can be found in Table 1.

Table 1. Assessment Criteria

Criteria	Scoring Scale
Very High	4
Height	3
Low	2
Very low	1

Source: (Rahmawati et al., 2019)

The formula used to analyze questionnaire results is the percentage of the ideal. The obtained score is divided by the maximum possible score and then multiplied by 100%. The calculated percentage informs the product certification criteria and determines the product's feasibility level. The efficiency of the media is determined using a student response questionnaire, which will be elaborated upon further in the results and discussion section.

RESULTS AND DISCUSSION

This research primarily focuses on the development of the Si-GEMAS crossword puzzle, targeting geometric operations such as geometric elements, properties, diagonals, areas, and volumes of space. The final product, an engaging game media, is intended to enhance students' critical thinking skills in mathematics, which will be detailed in the subsequent stages.

Potential and Problem

Data was accumulated during the needs and materials analysis phases. The research required meticulous analysis, involving interviews and observations to discern the prevalent issues in the selected school, YALC Pasuruan. Many students reported a sense of monotony in their learning experiences, especially in relation to mathematics, a subject often associated with a myriad of formulas, subsequently diminishing their interest. Additionally, students also faced difficulties in drawing conclusions when presented with diverse arguments in mathematical problem-solving. Based on these issues, two primary solutions were identified: a) Needs analysis: There is an evident requirement for engaging, enjoyable learning media capable of fostering students' critical thinking skills in learning geometric material, with consistent problem-solving exercises; b) Material analysis: The necessary data encompasses media design elements like shapes, materials, colors, an orderly distribution of math crossword puzzle materials per class level, and questionnaires for material experts, media design experts, and students. The distribution of material and questions for each level using the Si-GEMAS media is illustrated in Figure 2, featuring indicators of critical thinking skills.

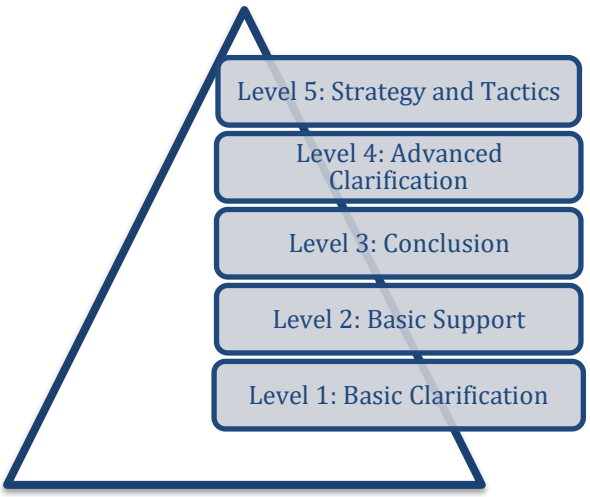

Figure 2. Materials and Questions in Si-GEMAS Media

Design

The Si-GEMAS media was conceived as a resource for teaching geometry. The design phase involves determining materials for geometry, incorporating five indicators of critical thinking skills (Levels 1-5: Basic Clarification, Basic Support, Conclusion, Advanced Clarification, Strategy, and Tactics) (Darmayanti, Sugianto, & Muhammad, 2022), geometrical properties, calculating unknown side lengths, diagonals, perimeters, areas, and volumes of planar shapes. Reference books, other source books, and scientific articles indexed at least by Sinta three related to mathematical crosswords were utilized. The design of the Si-GEMAS media, digital in form, was created with the assistance of the Canva application. It's accessible for student downloads, can be completed directly, and supports both online and offline usage. Access to the succeeding levels is coded to only permit progress once the preceding level is successfully completed. Si-GEMAS is designed with an aesthetically pleasing, varied, and communicative color scheme that appeals to students. It provides information through questions and diagrams about planar shapes, incorporates critical thinking skills, and adheres to good writing standards. The preliminary design remains in the draft or storyboard phase, with further development planned for subsequent stages.

Develop

The Si-GEMAS game, developed as a visual aid to enhance learning of mathematics, specifically planar shapes and critical thinking skills, has been validated by two experts - teachers from YALC Pasuruan. These experts were entrusted with evaluating the compatibility of the materials, game media used, and the design of the Si-GEMAS game. A validation questionnaire, comprising the Si-GEMAS Media Questionnaire Material and Si-GEMAS Media Questionnaire Design, facilitated the validation process. Evaluation results for all aspects were measured on a Likert scale, as depicted in Table 1. This method establishes an individual's stance on a spectrum of attitudes towards objects (Vidyastuti et al., 2022).

Si-GEMAS mathematical game design has been validated by experts in both media and material aspects, with aspects displayed in Figures 3 and 4.

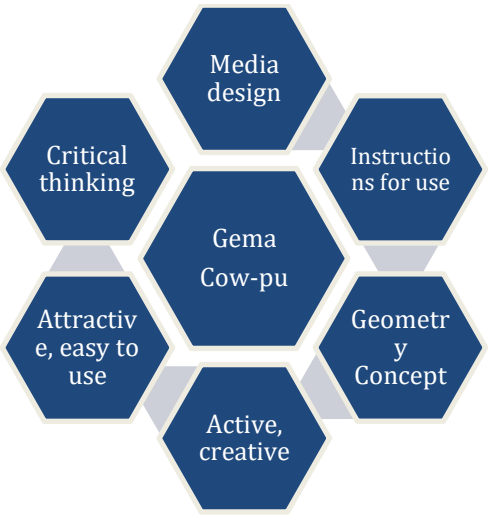

Figure 1. Si-GEMAS Media Components (Eriana et al., 2019)

Figure 3 showcases specific elements within the Si-GEMAS media. These elements, having undergone expert validation, include: (a) media design tailored to the manipulation of numerical data for constructing planar shapes; (b) clear instructions for using the Si-GEMAS mathematical tool; (c) the absence of conceptual errors; (d) a design conducive to development; (e) engaging students actively in learning; (f) assisting students in understanding planar shape materials; (g) attractive use of colors and shapes in the Si-GEMAS mathematical media; (h) enhancing students' capacity to develop mathematical critical thinking skills; (i) user-friendly and efficient interface; (j) reusable nature; (k) portability; (l) capacity of Si-GEMAS Mathematics to stimulate rapid and precise thinking; (m) easy storage and durability of Si-GEMAS Math. The Si-GEMAS media component depicted in Figure 4 focuses on material aspects.

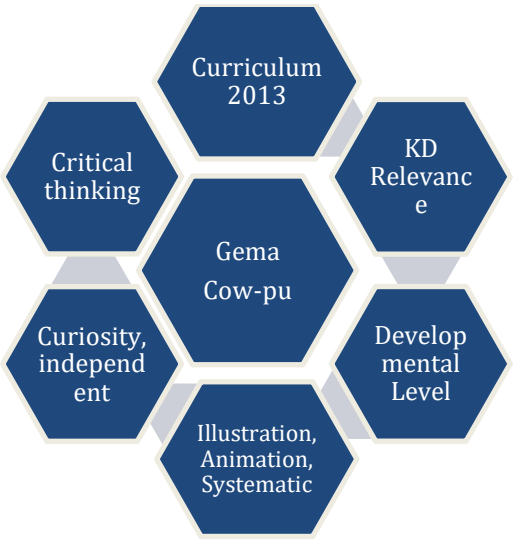

Figure 4. Material Components of Si-GEMAS (Hasanah, In'am, et al., 2022)

Figure 4 represents various components of the Si-GEMAS media from a material perspective. The elements, verified by experts, encompass: (a) mathematical content of Si-GEMAS pertaining to planar shape construction; (b) correlation with the skills students ought to master; (c) variation of planar shape manipulation content in Si-GEMAS according to

students' developmental stage; (d) alignment of instructional materials with curriculum requirements; (e) functional mathematical illustrations within Si-GEMAS; (f) inclusion of critical thinking indicators within Si-GEMAS media competencies; (g) exclusive focus on planar geometric content in each mathematical Si-GEMAS material; (h) potential of the presented material to spark students' curiosity; (i) presentation of material that stimulates problem-solving thinking; (j) material encouraging autonomous learning; (k) fostering student-initiated knowledge construction; (l) systematic arrangement of vertical and horizontal Si-GEMAS materials. The findings of the questionnaire verification for media and material experts regarding the Si-GEMAS Mathematical game media are summarized in Table 2.

Table 2. Validation Results of media and material experts on Si-GEMAS Media

No.	Rating Type	Aspect	Expert Validation	Score	Categories
1	Theory	ABCD EFGH IJKL	2 experts	89.4 %	Excellent
2	Media	a, b, c, d, e, f, g, h, i, j, k, l, m	2 experts	90.1%.	Excellent

Media design experts appraised the developed Si-GEMAS media as elementary in use, a tool that promotes quick and accurate thinking, enhances students' critical thinking skills, among other component aspects, scoring 90.1 percent in the "excellent" category. Along with the validation of Si-GEMAS media design aspects, material-related aspects were also expert-validated. The material experts deemed the Si-GEMAS math game aspect as scoring 89.4 percent in the "excellent" category. Subsequently, Table 3 compiles the validation of Si-GEMAS media by material and media experts.

Table 3. The Mean Results of Si-GEMAS Media Validation

Rating Type	Expert Validation	Total Score	Average Score	Categories
Theory and Media	Four experts	179.5 percent	89.75	Excellent and Doable

Table 3 demonstrates that design and material experts rate the Si-GEMAS media on students' critical thinking skills as exceptional, effectively facilitating the comprehension of mathematical concepts, particularly those related to planar geometry, with a score of 89.75 percent. This suggests that the Si-GEMAS media is an ideal tool for studying planar geometric material, specifically for nurturing and developing students' critical thinking abilities. Silberman's views on Si-GEMAS reinforce this finding as a strategy for concept repetition. The Si-GEMAS approach elucidates previously learned concepts and reviews the acquired skills and knowledge.

Design Revision

During the design revision phase, the Si-GEMAS media concentrates on refining the product designs that have been validated by experts. Any identified weaknesses are adjusted to enhance the overall product. Should the product be deemed inadequate, experts will revise and reevaluate it. Limited product trials can be conducted if the product proves truly effective. The Si-GEMAS media, developed based on the validation results of material experts and media design experts, falls within the "Highly Feasible" or "Excellent" category, thus negating the need for modifications. Consequently, the revised Si-GEMAS media can progress to the next phase of trials.

Trial

A limited product test involving the Si-GEMAS media was conducted on a small sample of ten students at SMA YALC Pasuruan. This test was carried out following the validator's verification of the validation results. The aim of this phase is to procure suitable instructional materials. A product is deemed effective if it can be implemented without undue difficulty. Aspects of evaluating student responses (Anjarwati et al., 2023) include: (a) Si-GEMAS media's ability to clarify mathematical concepts using flat-sided spatial material; (b) more enjoyable learning experience with Si-GEMAS; (c) the capacity of Si-GEMAS media to develop critical thinking skills in a step-by-step process at each level; (d) more active engagement in learning mathematics with Si-GEMAS; (e) appealing visual display of Si-GEMAS math; (f) facilitation of area and volume calculations using mathematical crossword puzzles; (g) quick learning curve for using Si-GEMAS; (h) efficient problem-solving with Si-GEMAS; (i) confidence in solving planar geometric problems with Si-GEMAS; (j) capacity for self-instruction through the use of Si-GEMAS; (k) enhanced enjoyment of learning mathematics with Si-GEMAS. Table 4 compiles the results of a questionnaire assessing student responses to the Si-GEMAS math game media.

Table 4. The Results of the Student Response Assessment Questionnaire on Si-GEMAS Media

Student	Observed aspect	Total Score	Category
10 Children	a, b, c, d, e, f, g, h, i, j, k	95.3 percent	efficient

Responses from a limited trial involving ten YALC Pasuruan students reveal a general enthusiasm for the Si-GEMAS media, noting its engaging and comprehensible nature. The overall approval rating stands at 95.3 percent, indicating the simplicity of the Si-GEMAS mathematical crossword game medium. Its attractive design, ease of use, and capacity to foster positive changes such as increased self-confidence, eagerness to learn, and independent learning have been highlighted. In line with student responses recorded in Table 4, all these improvements were accomplished using the Si-GEMAS media. The trial involved a mathematical crossword puzzle on critical thinking skills featuring planar geometric content. Among the ten students, the math crossword was deemed manageable. This aligns with the results of a student survey, where 93.3% asserted that using the crossword simplified their understanding of the concept. This finding corroborates the notion (Ramadhania & Adnan, 2022) that real-life experiences should be introduced into the classroom environment. According to Sadiyah et al., (2019), one of the key functions of teaching tools is to make learning more tangible. Additionally, if suitable instructional materials are characterized by appealing designs and colors, and can clarify mathematical concepts (Sadiyah et al., 2019), the developed teaching materials are deemed adequate, with Mshayisa (2020) noting a 100% approval rating. This implies unanimous agreement among students that the presentation of the puzzle was a highly engaging mathematical crossword.

Product Revision

Si-GEMAS game media, having undergone successful trials, has been revised based on the trial outcomes. The resulting mathematical crossword game media, tested and revised, are proven effective tools. This type of media is categorized under stereoscopic video media. Wijaksono S & Siddik, (2022) elucidated that 3D visual media are tangible media containing

elements such as lines, shapes, colors, and textures. The Si-GEMAS game media targets the construction of planar spaces and the development of critical thinking skills among grade VIII junior high school students. A depiction of the Si-GEMAS math media, tested for validity and efficiency, is provided below.

Figure 5. Display of Si-GEMAS Media at level 1

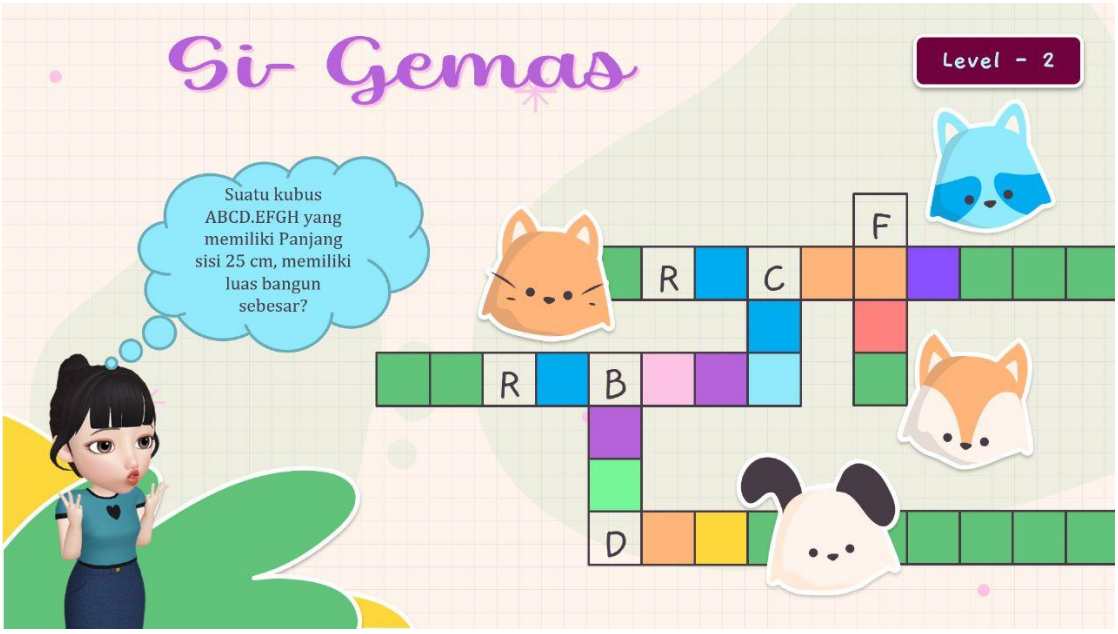

Figure 6. Display of Si-GEMAS Media at level 2

The achievement of seven development stages, as outlined in the Borg & Gall model, facilitated the smooth operation and realization of the expected results in this study. The aim of the research was to create a product—Si-GEMAS—that enhances students' critical thinking abilities in the "planar geometry" area, validating its efficiency. This validation and efficiency are evident in the responses received from the questionnaires. Generally, the validity of Si-

GEMAS in mathematics can be observed in the artistic and material authenticity and utility of the mathematical crossword puzzles. Si-GEMAS in mathematics has been developed in alignment with students' expectations, objectives, and necessities. The results from the Si-GEMAS crossword test have been positive, reflecting well on Si-GEMAS in the realm of mathematics.

Si-GEMAS constitutes a serious game that promotes a learning-while-playing atmosphere for students. The pleasure or displeasure felt in learning with serious games shapes the satisfaction derived from the learning process. Positive feelings emerge when students derive satisfaction from self-appreciation. This level of satisfaction can significantly influence learning outcomes and the development of critical thinking.

Ultimately, the use of Si-GEMAS as a Serious Game Mathematical Crossword Puzzle Learning Media has been shown to enhance students' critical thinking abilities. The analysis of the five-question test showed that students' critical thinking scores improved substantially from an average of 65.67 to 88.28—an impressive increase of 22.61. Emphasizing and enhancing critical thinking skills is crucial for problem-solving, as corroborated by Fadhlullah & Ahmad (2017). These skills allow students to process and differentiate information and opinions, foster curiosity, and develop unique perspectives.

Students have described Si-GEMAS mathematics as engaging, motivating, and conducive to developing critical thinking skills in understanding planar geometric concepts. Si-GEMAS Mathematics media requires no revisions and serves to reinforce students' understanding of planar shapes and foster their critical thinking skills.

CONCLUSIONS

The findings from the development of mathematical crossword puzzle media are as follows: (a) The Si-GEMAS media's adequacy for planar geometric material is considered to be highly satisfactory; (b) The Si-GEMAS game media's efficiency in conveying planar geometric concepts was demonstrated in a small group trial, garnering an efficiency rating of 95.3 percent. This indicates that the developed mathematical crossword puzzle media is efficient, encourages learning, fosters students' critical thinking skills, and is easy to use for learning purposes. This study's results encourage future researchers to explore engaging math learning methodologies, resulting in more diverse learning environments, expand expert input, and enhance the mathematical crossword media by involving test subjects with varying mathematical abilities to augment the quality of research.

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AUTHOR CONTRIBUTIONS STATEMENT

TL played a crucial role in the conceptualization of research ideas and data collection. DPW was instrumental in the study's conceptualization, design, interpretation of results, initial manuscript drafting, manuscript revision, final manuscript preparation, and securing funding. RD contributed to the drafting of the manuscript, statistical analysis, and provided

administrative and technical support. CH was involved in data analysis, computational statistics, and interpretation of results. US also played a supervisory role in the project, providing critical feedback, and shaping the research, analysis, and manuscript.

REFERENCES

Agarwal, H. K., Singhal, A., & Yadav, A. K. (2020). Crossword puzzle: An innovative assessment tool to improve learning of students in forensic medicine. *Medico-Legal Update*, *20*(1), 18–22.

Alphonce, S., & Mwantimwa, K. (2019). Students' use of digital learning resources: Diversity, motivations and challenges. *Information and Learning Sciences*, *120*(11/12), 758–772.

Alpusari, M., Mulyani, E. A., Hermita, N., & Putra, E. D. (2020). Improving fourth grade students' critical thinking skills with MIKIR approach. *Journal of Teaching and Learning in Elementary Education (JTLEE)*, *3*(2), 192–199.

Anjarwati, S., Darmayanti, R., & Khoirudin, M. (2023). Development of "material gaya" teaching materials based on creative science videos (CSV) for Class VIII Junior High School Students. *Jurnal Edukasi Matematika dan Sains*, *11*(1), 163–172.

Arisoy, B., & Aybek, B. (2021). The effects of subject-based critical thinking education in mathematics on students' critical thinking skills and virtues*. *Eurasian Journal of Educational Research*, *2021*(92), 99–120.

Bar, A., & Otterbring, T. (2021). The role of culture and personality traits in board game habits and attitudes: Cross-cultural comparison between Denmark, Germany, and USA. *Journal of Retailing and Consumer Services*, *61*, 102506, 73-90.

Cardinot, A., McCauley, V., & A Fairfield, J. (2022). Designing physics board games: A practical guide for educators. *Physics Education*, *57*(3), 035006, 1–12.

Chen, H.-J. H., & Hsu, H.-L. (2020). The impact of a serious game on vocabulary and content learning. *Computer Assisted Language Learning*, *33*(7), 811–832.

Danilovic, S., & de Voogt, A. (2021). Making sense of abstract board games: Toward a cross-ludic theory. *Games and Culture*, *16*(5), 499–518.

Darmayanti, R., Baiduri, B., & Inganah, S. (2022). Moodle-based learning media development of flex model in improving mathematical hard skills of high school students. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(4), 2649–2665.

Darmayanti, R., Sugianto, R., Baiduri, B., Choirudin, C., & Wawan, W. (2022). Digital comic learning media based on character values on students' critical thinking in solving mathematical problems in terms of learning styles. *Al-Jabar : Jurnal Pendidikan Matematika*, *13*(1), 49–66.

Darmayanti, R., Sugianto, R., & Muhammad, Y. (2022). Analysis of students' adaptive reasoning ability in solving HOTS problems arithmetic sequences and series in terms of learning style. *Numerical: Jurnal Matematika dan Pendidikan Matematika*, 73–90.

Eriana, Kartono, & Sugianto. (2019). Understanding ability of mathematical concepts and students' self-reliance towards learning by implementing manipulative props (APM) on jigsaw technique article info. *Journal of Primary Education*, *8*(2), 176–183.

Fadhlullah, A., & Ahmad, N. (2017). Thinking outside of the box: Determining students' level of critical thinking skills in teaching and learning. *Asian Journal of University Education*, *13*(2), 51–70.

Fukuda, K. (2020). Science, technology and innovation ecosystem transformation toward society 5.0. *International Journal of Production Economics*, *220*, 107460, 1–14.

Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: How effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning*, *29*(3), 207–219.

Güner, P., & Erbay, H. N. (2021). Prospective mathematics teachers' thinking styles and problem-solving skills. *Thinking Skills and Creativity*, *40*, 100827, 1–14.

Haftador, A. M., Shirazi, F., & Mohebbi, Z. (2021). Online class or flipped-jigsaw learning ? Which one promotes academic motivation during the COVID-19 pandemic? *BMC Medical Education*, *21*(1), 499, 1–8.

Hasanah, N., In'am, A., Darmayanti, R., Choirudin, C., Nurmalitasari, D., & Usmiyatun, U. (2022). Development of Al-qur'an context math e-module on invers function materials using book creator application. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(4), 3502–3513.

Hasanah, N., Syaifuddin, M., & Darmayanti, R. (2022). Analysis of the need for mathematics teaching materials "digital comic based on islamic values" for class X SMA students in era 5.0. *Numerical: Jurnal Matematika dan Pendidikan Matematika*, *6*(2), 231–240.

Herawati, H. (2022). Critical thinking and meaningful learnings in online learning: Do both make increases?. *Jurnal Pendidikan Ilmu Sosial*, *32*(1), 1–13.

Inganah, S., Darmayanti, R., & Rizki, N. (2023). Problems, solutions, and expectations: 6C integration of 21 st century education into learning mathematics. *JEMS (Journal of Mathematics and Science Education)*, *11*(1), 220–238.

Iten, N., & Petko, D. (2016). Learning with serious games: Is fun playing the game a predictor of learning success? *British Journal of Educational Technology*, *47*(1), 151–163.

Loh, C. S. (2009). Researching and developing serious games as interactive learning instructions. *International Journal of Gaming and Computer-Mediated Simulations*, *1*(4), 1–19.

McAdoo, R. M., Key, K. N., & Gronlund, S. D. (2019). Task effects determine whether recognition memory is mediated discretely or continuously. *Memory & Cognition*, *47*(4), 683–695.

Meirbekov, A., Maslova, I., & Gallyamova, Z. (2022). Digital education tools for critical thinking development. *Thinking Skills and Creativity*, *44*, 101023.

Moloney, J., Globa, A., Wang, R., & Roetzel, A. (2017). Serious games for integral sustainable design: Level 1. *Procedia Engineering*, *180*, 1744–1753.

Morozova, M., Gula, L., Dymar, N., Diachenko, I., & Bykadorova, N. (2022). Influence of critical thinking technologies on improvement of students performance during self-study. *Journal of Curriculum and Teaching*, *11*(1), 59–72.

Mshayisa, V. V. (2020). Students' perceptions of Plickers and crossword puzzles in undergraduate studies. *Journal of Food Science Education*, *19*(2), 49–58.

Niculescu, V., & Ştefănică, R. M. (2022). Tries-based parallel solutions for generating perfect crosswords grids. *Algorithms*, *15*(1), 22, 1–17.

Nugroho, P. B., Nusantara, T., As'ari, A. R., Sisworo, S., Hidayanto, E., & Susiswo, S. (2018). Critical thinking disposition: Students skeptic in dealing with Ill-logical mathematics problem. *International Journal of Instruction*, *11*(3), 635–648.

Oracion, Q. J. G., & Abina, I. L. S. (2021). The mediating effect of students' attitude to student career aspiration and mathematics achievement. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, *6*(3), 158–173.

Perini, S., Luglietti, R., Margoudi, M., Oliveira, M., & Taisch, M. (2018). Learning and motivational effects of digital game-based learning (DGBL) for manufacturing education –The Life Cycle Assessment (LCA) game. *Computers in Industry*, *102*, 40–49.

Rachmavita, F. P. (2020). Interactive media-based video animation and student learning motivation in mathematics. *Journal of Physics: Conference Series*, *1663*(1), 012040, 1–6.

Rahmawati, N. S., Bungsu, T. K., Islamiah, I. D., & Setiawan, W. (2019). Analisis minat belajar siswa MA Al-Mubarok melalui pendekatan saintifik berbantuan aplikasi geogebra pada materi statistika dasar. *Journal On Education*, *01*(03), 386–395.

Ramadhania, S., & Adnan, H. (2022). Crossword puzzle learning media to improve indonesian vocabulary mastery for Grade 2 Elementary School Students. *Journal of Innovation and Research in Primary Education*, *1*(2), 50–55.

Sadiyah, W. H., Septiani, W., & Kareviati, E. (2019). Improving english vocabulary mastery by using crossword puzzle. *project (Professional Journal of English Education)*, *2*(2), 110, 9–13.

Scott, D., Knowles, N. L. B., Ma, S., Rutty, M., & Steiger, R. (2023). Climate change and the future of the Olympic Winter Games: athlete and coach perspectives. *Current Issues in Tourism*, *26*(3), 480–495.

Siburian, J., Corebima, A. D., Ibrohim, & Saptasari, M. (2019). The correlation between critical and creative thinking skills on cognitive learning results. *Eurasian Journal of Educational Research*, *2019*(81), 99–114.

Song, D., & Bonk, C. J. (2016). Motivational factors in self-directed informal learning from online learning resources. *Cogent Education*, *3*(1), 1205838, 1–11.

Ullah, M., Amin, S. U., Munsif, M., Safaev, U., Khan, H., Khan, S., & Ullah, H. (2022). Serious games in science education: A systematic literature review. *Virtual Reality & Intelligent Hardware*, *4*(3), 189–209.

Vidyastuti, A. N., Effendi, M. M., & Darmayanti, R. (2022). Aplikasi tik-tok: Pengembangan media pembelajaran matematika materi barisan dan deret untuk meningkatkan minat belajar siswa SMA. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah di Bidang Pendidikan Matematika*, *8*(2), 91–106.

Wati, D. R., & Suhardi, A. (2022). Development of eclipse crossword assisted crossword learning media in digestive system materials in Junior High School. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *3*(1), 43–55.

Wijaksono S, D. N. H., & Siddik, A. H. R. (2022). The effectiveness of using crossword puzzle games through student's vocabulary mastery. *JOEY: Journal of English Ibrahimy*, *1*(1), 1–10.