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Bridging conceptual understanding and mathematical representation through game-based cuboid learning in junior high school

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Abstract

In the era of modernisation, conceptual understanding and mathematical representation are key components of education. However, many students still encounter difficulties in understanding and accurately representing rectangular prisms. This study addresses the need for innovative learning by examining students' experiences in understanding and representing rectangular prisms through a Role-Playing Game-based educational game and module. This study employed a qualitative method to understand the experiences of 17 eighth-grade junior high school students in learning rectangular prisms through an RPG game and a supplementary module. Data were collected through observation, module analysis, and documentation and then analysed thematically. The findings revealed that while some students found it easier to grasp concepts through visual exploration, others struggled to apply these concepts flexibly beyond the game. Students who actively engaged in gameplay demonstrated a deeper understanding and were better able to make meaningful conceptual connections. Although verbal representation improved significantly, symbolic representation remained challenging for some students. This study emphasises the importance of designing educational games that support conceptual understanding and representation skills. The implications of this study highlight the need for the development of interactive learning media that can facilitate students' conceptual connections and foster their mathematical representation skills.

Keywords: conceptual understanding; mathematical representation; role-playing game-based

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Introduction

Mathematics is a core subject in the Indonesian educational curriculum, aiming to equip students with logical, analytical, innovative, and critical thinking skills, as well as the ability to collaborate effectively (Prajono et al., 2022). In the face of increasingly complex global challenges, the ability to comprehend mathematical concepts and representations is crucial for adapting to rapid and dynamic changes. Mathematical understanding is vital for students and becomes more meaningful when constructed independently, allowing better conceptual retention (Pramuditya et al., 2021). Conceptual understanding in mathematics involves the ability to comprehend, distinguish, and apply concepts across a range of situations (Khairani et al., 2021). This aligns with Hutagalung (2017), who argued that conceptual understanding includes the ability to restate mathematical concepts in one's own words, classify mathematical objects, and make connections between different concepts.

Mathematical representation skills refer to students' ability to express mathematical ideas and concepts through various forms, such as diagrams, tables, graphs, numbers, letters, symbols, and other representational modes, to solve problems (Agusfianuddin et al., 2024; Duval, 2006; Hardianti & Effendi, 2021). These skills reflect students' thought processes in understanding mathematical concepts, operations, and ideas (Asnawati & Dewi, 2020). Representational ability is essential for formulating and communicating mathematical ideas by transforming abstract forms into more concrete representations to aid comprehension (Choerunnisa et al., 2024; Kurniadi et al., 2021; Rahmawati et al., 2021). When students build their own representations, they effectively solve problems and explore mathematical ideas, enabling them to understand concepts and construct meaningful, systematic solutions (Asnawati & Dewi, 2020).

Despite the importance of conceptual understanding and mathematical representation, many students continue to struggle with grasping the material, particularly in topics such as three-dimensional rectangular solids (cuboids). Asril and Fatmawati (2021) revealed that students often have difficulty understanding the concept of rectangular solids and are unable to represent related problems mathematically. This challenge is frequently attributed to conventional teaching methods that rely heavily on teacher explanations and repetitive exercises, resulting in a lack of student engagement (Abakah & Brijlall, 2024; Andriani et al., 2024). Monotonous and uncreative instruction can lead to disinterest, reduced concentration, and ineffective learning (Fatahillah & Faradillah, 2023; Febriani et al., 2023).

To address these issues, innovative and engaging instructional approaches are needed. Technological development offers opportunities to create enjoyable and interactive learning environments (Gurmu et al., 2024). One promising solution is the use of educational games, which can increase student engagement and facilitate their mathematical abilities in a more interactive manner. Educational games that integrate instructional elements have been shown to be effective in alleviating students' boredom when learning mathematics (Pramuditya et al., 2022). These games can serve as appealing and enjoyable learning media, structured to encourage student interaction and participation (Pramuditya et al., 2018a, 2018b).

One particularly engaging game-based learning approach is the Role-Playing Game (RPG). RPGs not only offer an enjoyable learning experience but also help students understand and represent mathematical concepts more deeply through exploration and in-game interactions (Azzumar et al., 2019). RPGs allow students to assume roles as characters and explore virtual worlds while learning mathematical concepts, including three-dimensional rectangular solids (Pramuditya et al., 2017). These games can be designed to present challenges and problems related to rectangular solids, encouraging students to understand and apply theoretical concepts in a gaming context (Putra, 2023; Rhamadhan & Haerudin, 2024). Furthermore, Pramuditya et al. (2017) found that using RPGs in mathematics instruction fosters student interaction and discussion, enabling collaboration in solving mathematical challenges and reinforcing understanding through shared reflection. Additional studies have found RPGs to be effective learning tools for improving students' mathematical understanding (Fikriah & Fiangga, 2024). However, despite the growing evidence of the effectiveness of RPGs in mathematics education, there remains a limited understanding of how RPGs specifically support the conceptual representation and understanding of cuboids. In particular, few studies have explored how RPGs can be effectively integrated with learning modules and group discussions to enhance students' abilities to represent cuboids using visual, symbolic, and verbal forms. This study addresses this gap by investigating the potential of RPGs, when combined with collaborative and reflective activities, to deepen students' understanding of cuboid concepts within a blended learning environment.

Previous studies have shown that the use of digital media, such as educational games, can enhance students' conceptual understanding of mathematics (Laswadi et al., 2024). Other studies have highlighted the importance of mathematical representation in supporting conceptual comprehension; however, few have integrated both elements within a single instructional approach (Hidayat et al., 2023; Monariska & Komala, 2021). This study offers a novel contribution by combining an RPG-based educational game with a supplementary module as an exploratory medium to reveal and develop students' conceptual understanding and mathematical representation skills. This approach enables students to understand the concept of rectangular prisms and to represent their mathematical ideas more deeply within an interactive and meaningful learning context.

Based on the considerations above, this study aims to analyse junior high school students' conceptual understanding and mathematical representation abilities through the use of RPG-based learning media supported by learning modules, focusing on the topic of rectangular prism solids. This research is grounded in a conceptual framework that links the game-based learning approach to the development of conceptual understanding and mathematical representation. In this context, RPG function as interactive mediums that encourage active student engagement in solving mathematical problems verbally and symbolically. The learning modules support this process by reinforcing the conceptual structure and providing space for students to systematically represent their mathematical ideas. By integrating these two media, it is expected that students can build a deeper understanding and stronger representation skills related to the concept of rectangular prism solids.

Methods

This study employed a qualitative case study approach to understand students' experiences of learning through an RPG game focused on rectangular prisms. The research subjects consisted of 17 eighth-grade junior high school students divided into four groups based on their performance in the accompanying student learning and playing module on rectangular prisms using the RPG game. Eighth grade was chosen because the topic of rectangular prisms is part of the 2013 Curriculum in the mathematics subject for eighth-grade junior high school students.

Data collection techniques included direct observation, analysis of the accompanying modules, and documentation. Direct observation was conducted during the learning process by observing students' interactions with the RPG and how they solved mathematical challenges within it. Observations were systematically recorded using field notes and video documentation to validate and strengthen the research findings. Additionally, the accompanying module, which contained students' answers to questions embedded in the game, was analysed with a focus on students' conceptual understanding and mathematical representation abilities based on predetermined indicators.

The instrument used in this study consisted of questions designed to assess students' conceptual understanding and mathematical representation skills, which were aligned with the two indicators. The indicators for conceptual understanding used in this study were adapted from those developed by the National Council of Teachers of Mathematics (2000) and are presented in Table 1.

Table 1. Indicators of conceptual understanding ability

No.	Indicators
1	Restating a concept
2	Classifying an object based on specific attributes in accordance with the concept.
3	Providing examples and non-examples of a concept
4	Representing the concept in various forms of mathematical representation

The indicators of mathematical representation ability used in this study are adapted from those proposed by Hilmi (2023), as presented in Table 2.

Table 2. Indicators of mathematical representation ability

No.	Indicator	Description
1	Symbolic representation ability	The ability to solve problems by correctly applying mathematical expressions or models.
2	Verbal representation ability	The ability of students to accurately answer questions using written or spoken language.

To ensure the validity of the instrument, the questions embedded in the module were reviewed by two mathematics education experts to assess their alignment with the indicators of conceptual understanding and of mathematical representation. The experts provided feedback on the clarity, relevance, and appropriateness of the questions in capturing the intended constructs. Based on this expert judgment, several items were revised to better align with the indicators of the study. Regarding reliability, as this study employed a qualitative approach, the consistency of the instrument was ensured through methodological triangulation. The students' responses were cross-validated with field notes and video documentation during the learning sessions. This triangulation helped ensure the trustworthiness and reliability of the data by confirming that the students' written responses accurately reflected their actions and verbal expressions during the learning process.

The data obtained from students' responses in the accompanying module were manually analysed by referring to the predetermined indicators of conceptual understanding and mathematical representation. The data analysis process involved three stages: data reduction, thematic categorisation, and conclusion drawing, with a focus on how students interpreted their learning experiences in understanding rectangular prism concepts and how these experiences shaped their symbolic and verbal representations.

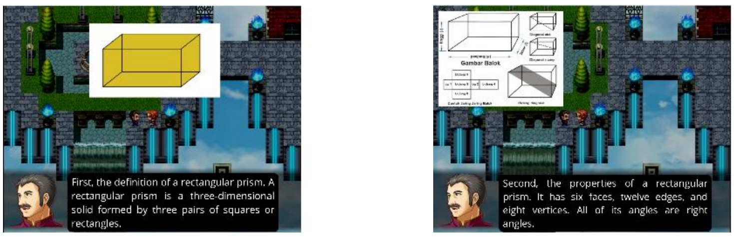
Additionally, learning documentation and field notes were used to validate the interpretation of students' responses, ensuring the validity and trustworthiness of the findings. Thus, this data analysis process not only focused on the content of students' answers but also emphasised the meaning of their learning experiences and their ability to represent mathematical concepts symbolically and verbally, aligning with the research objectives.

Results

Students' experience in understanding the concept of rectangular prisms

In this study, students' mathematical conceptual understanding was measured using four indicators adapted from the framework developed by the National Council of Teachers of Mathematics. However, the discussion focuses on only two of these indicators, as they are considered the most relevant to the research objectives and better reflect students' understanding within the context of using an educational game. Additionally, limitations in data and the scope of the study were taken into account in selecting which indicators to discuss.

To illustrate how students interacted with the concept of rectangular prisms, Figure 1 shows a screenshot of the RPG-style educational game that addresses the definition and characteristics of rectangular prism shapes.

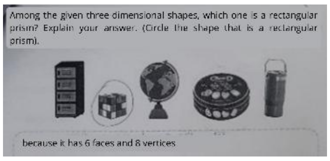


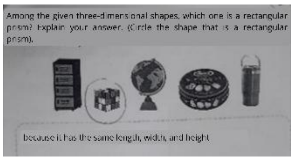
(a) (b)

Figure 1. (a) Definition of rectangular prism; (b) Characteristics of rectangular prism

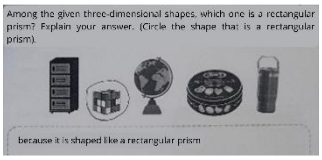
Identification of a rectangular prism

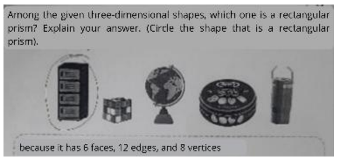
The observation results indicate that students exhibit varying levels of understanding regarding rectangular prisms through the use of an RPG game. Most students find it easier to grasp the concept through visual exploration, as it allows them to interactively observe the shape of the rectangular prism and compare it with other three-dimensional figures.





(a) (b)





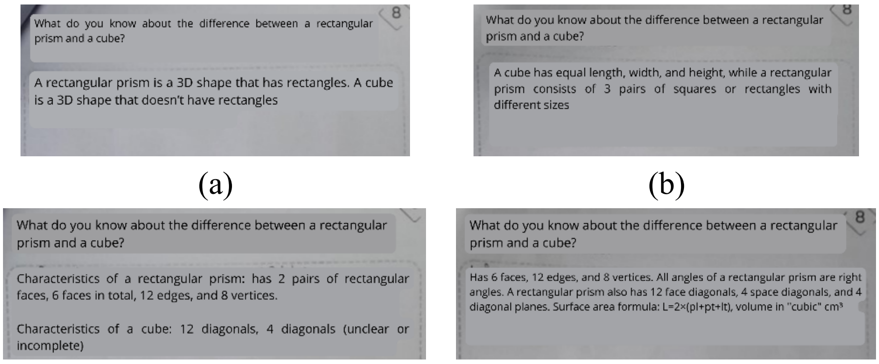
(c) (d)

Figure 2. (a) Response to Question 1 by Student K1; (b) Response to Question 1 by Student K2; (c) Response to Question 1 by Student K3; (d) Response to Question 1 by Student K4

In Figure 2, students were tasked with identifying rectangular prisms (cuboids) from several images of real-world objects. The students' responses varied, reflecting different levels of conceptual understanding of the characteristics of rectangular prisms. Figure 2(a) demonstrates a fairly good understanding of the characteristics of rectangular prisms, as the student correctly stated that *a rectangular prism has six faces and eight vertices*. However, the student did not explicitly mention that the faces are rectangular, and their identification of the real-life example of a rectangular prism was inaccurate. Figure 2(b) shows an incorrect response, as the student associated equal length, width, and height with rectangular prisms—properties that actually define a cube. This indicates a weak conceptual understanding, further evidenced by the student’s incorrect identification of a real-life example of a rectangular prism.

Figure 2(c) also reflects a poor understanding of the concept. The student's response was overly general and lacked conceptual justification, merely stating that the object was shaped like a rectangular prism without providing any reasoning. In Figure 2(d), the student answered, "*Because it has six faces, twelve edges, and eight vertices*," which indicates a correct understanding of the geometric properties of a rectangular prism. The student also successfully identified a cupboard as an example of a rectangular prism in everyday life. Therefore, this response demonstrates a very good level of conceptual understanding. However, some students still struggled to transfer the concept from the game environment to real-world contexts. Students who actively engaged with the exploration features of the game tended to have a better understanding, particularly in identifying the properties of rectangular prisms. In contrast, students who merely played the game without attempting to comprehend the underlying concepts found it difficult to articulate their understanding without visual support from the game.

The difference between a rectangular prism and a cube



(a) (b) (c) (d)

Figure 3. (a) Student response to Question 1, K1; (b) Student response to Question 1, K2; (c) Student response to Question 1, K3; (d) Student response to Question 1, K4

In Figure 3, students were asked to explain the differences between a rectangular prism (*balok*) and a cube (*kubus*). The students' responses varied, reflecting different levels of understanding regarding the characteristics of these three-dimensional shapes. The response in Figure 3(a) demonstrates a basic understanding but lacks clarity in concept articulation. The student correctly states that a rectangular prism has rectangular faces but provides an incomplete explanation by simply stating that a cube does not have rectangles. This indicates a limited understanding of how to distinguish between a rectangular prism and a cube. Figure 3(b) demonstrates a good level of understanding. The student recognizes that a cube has equal length, width, and height, and also understands that a rectangular prism has three pairs of square or rectangular faces, meaning that the faces of a rectangular prism vary in dimensions and are shaped as rectangles. In Figure 3(c), the student correctly identifies several key characteristics of a rectangular prism; however, the description of the cube is unclear and incomplete. The mention of "12 diagonals" and "4 diagonals" is not entirely accurate and requires clarification as to whether the student refers to face diagonals, space diagonals, or plane diagonals. This response indicates a moderate level of understanding of the differences between a rectangular prism and a cube. Figure 3(d) reflects a very strong understanding, as the response is both detailed and accurate. The student not only correctly describes the features of a rectangular prism but also adds additional information such as face diagonals, space diagonals, and diagonal planes. Moreover, the student includes the surface area formula of a rectangular prism, indicating a deeper conceptual grasp of this geometric solid. However, the response could have been even more comprehensive if the student had also described the characteristics of a cube to provide a clearer comparison. These results suggest that visual representations in the game were highly supportive, though additional strategies are still needed to help students connect these concepts to real-life contexts and express them symbolically and verbally.

Mathematical representation in RPG games

Symbolic representation

An analysis of the module indicates that most students were able to calculate the surface area of rectangular prisms. However, some students demonstrated a lack of precision in writing formulas and units. Several students tended to copy the formulas without fully understanding the rationale behind their use. To illustrate the type of questions presented to students through the RPG game, Figure 4 displays a multiple-choice question on calculating the surface area of a rectangular prism.

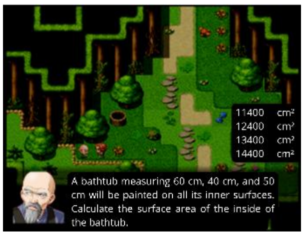


Figure 4. Surface area problem of a rectangular prism

Figure 5 below presents the students' written solutions and answers in the module after completing the problem from the game.

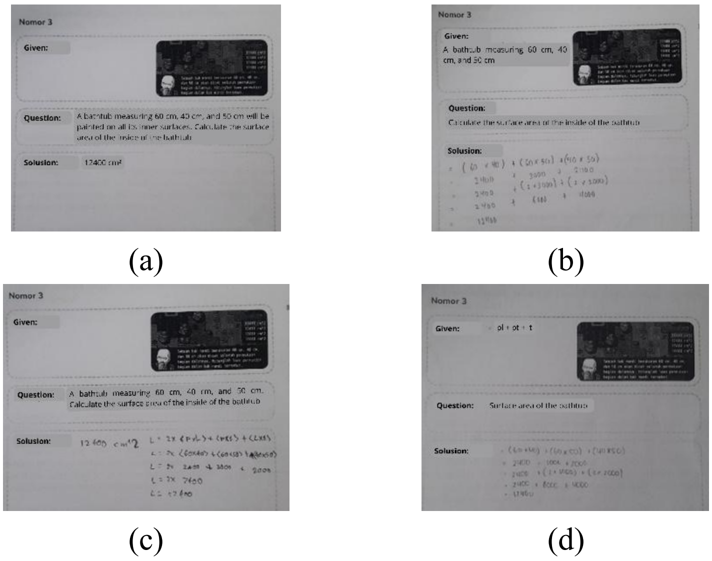


Figure 5. (a) Student's answer to the symbolic representation problem K1; (b) Student's answer to the symbolic representation problem K2; (c) Student's answer to the symbolic representation problem K3; (d) Student's answer to the symbolic representation problem K4

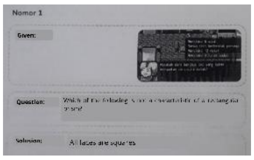
The students' work demonstrates that they have developed a solid understanding of the concept of the surface area of rectangular prisms, as evidenced by the correct final answer of 12,400 cm². However, there are noticeable differences in their symbolic representation skills. Figure 5(a) only provides the final answer without any supporting steps, indicating a lack of ability to communicate the mathematical process. In contrast, Figures 5(b) and 5(d) present well-structured steps but are less meticulous in including measurement units. Figure 5(c) illustrates that the student is capable of representing the concept comprehensively, including correct use of formulas, calculations, and units.

Verbal representation

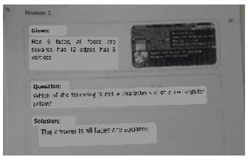
Most students were able to identify and describe the characteristics of rectangular prisms effectively. The RPG game helped reinforce their recall of these characteristics, although they still struggled to articulate them using formal language. To illustrate the type of question presented to students through the RPG game, Figure 6 displays a multiple-choice question that asks students to identify which of the listed options is *not* a characteristic of a rectangular prism.

Figure 6. about the characteristics of cuboids

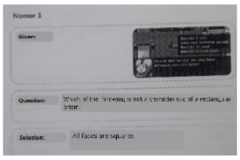
Figure 7 below presents the students' written solutions and answers in the module after they completed the questions from the game.



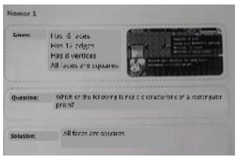
(a)



(b)



(c)



(d)

Figure 7. (a) Answer to the verbal representation question K1; (b) Answer to the verbal representation question K2; (c) Answer to the verbal representation question K3; (d) Answer to the verbal representation question K4

The students' results demonstrated a solid understanding of verbal and mathematical representation related to the characteristics of rectangular prisms. They were able to correctly identify key features, such as a rectangular prism having six faces, twelve edges, and eight vertices, and they understood that the faces of a rectangular prism are rectangles, not squares. In addition, they could reason accurately that the statement "all faces are squares" is not a defining characteristic of a rectangular prism, and they were able to distinguish incorrect information. This is further illustrated by the student's written answers shown in Figure 7, which are described in detail in the discussion section. Thus, the student's ability to represent and explain the properties of rectangular prisms verbally is considered to be good.

Discussion

Analysis of students' understanding

Based on the results of observations and data analysis, it was found that students who actively explored the features within the RPG game demonstrated a better understanding of the concept of rectangular prisms compared to those who engaged with the game passively. The exploratory activities within the game enabled students to recognize the interconnections between concepts and apply them in real-life contexts. Conversely, students with lower levels of engagement faced difficulties in transferring concepts from the virtual environment to everyday situations, indicating the need for additional instructional strategies to reinforce conceptual understanding.

This finding is illustrated by a student's remark during an interview:

Interviewer	:	Earlier, when you were playing the game, how did it make you feel?
S1	:	It was fun. But there were some parts that were a bit difficult when working on the tasks. Sometimes it was hard to figure out which direction to go.
Interviewer	:	Was it because the instructions weren't clear, or something else?
S1	:	Sometimes I got confused and didn't quite understand.

This response highlights both the engangement and the conceptual challenge they experienced. Such reflection suggest that while the game successfully captured students' attention, it also introduced authentic problem-solving scenarios that prompted deeper thinking.

Consistent with these findings, several previous studies have also demonstrated that students' active involvement in the learning process, particularly through exploring features within educational games, significantly contributes to enhanced conceptual understanding. Maharani et al. (2024) state that students who actively participate in educational games are better able to connect concepts effectively and apply them in real-world contexts compared to those who engage passively. Furthermore, Anwar and Jasiah (2025) and Zebua et al. (2024) found that active engagement in educational games increases students' motivation and their ability to transfer knowledge to everyday situations. Conversely, students who are less active tend to struggle with transferring concepts from virtual environments to real life, indicating the need for additional instructional strategies to strengthen conceptual understanding (Anwar & Jasiah, 2025; Najuah et al., 2022).

Although students who actively explored the features of the RPG game showed improved conceptual understanding, their ability to use symbolic representation remained relatively low. This indicates that the intervention through educational games has not been fully effective in developing the symbolic skills that are important in mathematics learning. This condition can be explained by cognitive load theory (Sweller, 2011), which states that transforming concrete experiences into abstract symbolic forms requires considerable mental effort. This is because the brain has to manage multiple pieces of information simultaneously and construct new schemas in long-term memory. Furthermore, according to Vygotsky's learning theory, students need assistance or scaffolding to connect direct experiences with symbolic concepts (Vygotsky, 1978). Although the game is engaging and motivates students, it may not sufficiently emphasize the development of symbolic skills specifically. Therefore, future learning strategies need to include activities that focus more on exercises to improve symbolic representation skills, such as encouraging students to practice converting concrete forms into symbols or images.

Moreover, these findings remind us that successful learning depends not only on how actively students are involved but also on the type and method of intervention provided. A more comprehensive approach that combines motivation, exploration, and symbolic reinforcement is essential to help students more easily apply concepts from the virtual environment to real-life situations.

Students' mathematical representation

In analyzing students' mathematical representation abilities, several notable trends were identified. Overall, students demonstrated a good understanding of the concept of the surface area of a rectangular prism, as reflected in the accuracy of their final answers. However, regarding symbolic representation, variations in ability were evident; some students were unable to present problem-solving steps systematically and completely, and inaccuracies in the use of measurement units were also observed. These findings underscore the importance of instructional approaches that emphasize not only the final outcomes but also the development of systematic and communicative mathematical thinking processes.

Students were also observed making sense of mathematical representations through their own language. One student, for example, stated, *"Because it was still the beginning, I could still remember how to solve it… and we also discussed it with friends."* suggesting that collaborative and game-based activities helped reinforce prior knowledge and fostered peer-supported learning. Another illustrative case involved a student who initially struggled to recall the geometric attributes of a rectangular prism:

Interviewer	:	So, was you able to explain or describe it again? For example, how many faces does a rectangular prism have?
S1	:	Six or eight? I forgot—one of those two.
Interviewer	:	But can you picture what a rectangular prism looks like?
S1	:	Yes, I can.

[The interviewer assisted the student in counting the faces using a drawing made by the student.]

S1	:	It has six faces.

This progression illustrates that scaffolded support, such as direct guidance and structured discussion, can help students overcome initial confusion and strengthen their understanding of mathematical concepts.

Additionally, in terms of verbal representation, students' participation in role-playing game (RPG) activities contributed positively to their ability to express ideas and construct narratives within mathematical contexts. Nevertheless, students still require guidance in composing more systematic and logically organized explanations. Overall, students' mathematical representation skills remain varied; while some are able to coherently document their thought processes, others tend to only present the final answer. Thus, a more intensive instructional approach is needed to strengthen both symbolic and verbal representational skills, fostering a deeper and more communicable understanding of mathematical concepts.

These findings align with the study conducted by Hermawan (2017), which demonstrated that the use of educational games, particularly Role-Playing Games (RPGs) and Puzzle RPGs, significantly enhances students' verbal representation abilities and their understanding of mathematical concepts. His study further emphasized that RPGs, when used as instructional media, can increase students' engagement and interaction in learning mathematics, thereby supporting systematic and communicative mathematical thinking processes, although challenges in logically organizing concepts persist.

The role of games in the learning experience

Observations indicate that most students appeared more engaged when learning through games compared to conventional methods. However, without proper guidance, some students tended to focus more on gameplay aspects rather than the underlying mathematical concepts. Therefore, the integration of games with structured learning modules through group discussions was implemented to help students explore concepts more systematically. Despite these benefits, students sometimes struggled to decode certain parts of the game. As one student reflected, *"Sometimes I get confused, and sometimes I don't quite understand.*" suggesting that while the game format is engaging, certain instructional supports (e.g., clearer instructions or scaffholding) are still necessary.

Research by Asnawati et al. (2018) and Tijani (2025) suggests that student-centered learning fosters active engagement, providing opportunities for students to discuss and formulate strategies as well as mathematical ideas collaboratively. Educational games play a significant role in bridging conceptual understanding and mathematical representation skills, as they allow students to interactively explore three-dimensional rectangular solids. With a solid grasp of the concepts, students are able to represent rectangular prisms in various forms—through illustrations, verbal descriptions, or real-life contextual explorations. Consistent with findings by Mustangin and Setiawan (2021), students with a strong conceptual understanding tend to perform better in solving mathematical problems, and the reverse also holds true. These findings underscore that the integration of educational games with discussion-based methods can enhance students' mathematical thinking skills as well as their ability to effectively communicate conceptual understanding.

Conclusion

This study demonstrates that RPG, when combined with the completion of learning modules in group discussions, can support students in understanding mathematical concepts and representations more effectively. The game's visual elements provide an interactive learning experience that enhances students' comprehension of rectangular prisms, while the discussions and module activities allow them to reflect on and communicate their understanding using various forms of mathematical representation.

The results of this study suggest that RPG-based educational games have strong potential to be used as a learning medium that encourages students' engagement and conceptual learning.

By integrating interactive media with collaborative learning, educators can create a student-centred learning environment, especially for abstract mathematical concepts, as was done in this study.

However, this study had several limitations. The research involved a small sample of 17 eighth-grade students from a single school and focused solely on the topic of rectangular prisms. The study employed only a qualitative approach without quantitative comparisons, such as pre- and post-tests. Additionally, technical issues occurred during implementation, such as unstable Internet access and limited functionality of students' devices. Time constraints during student interviews also affected the depth of data collection, as some interviews had to be shortened because of students' limited availability.

Based on these findings, curriculum developers are encouraged to integrate digital game-based learning with traditional instruction to enrich students' conceptual understanding and representation mathematical skills. Such efforts should be supported by improvements in learning infrastructure and teacher preparation to optimise classroom implementation.

Future research should focus on developing more adaptive RPG games that respond to students' varying needs and learning levels. It is also worth exploring the application of this RPG model to other mathematical topics and expanding the sample to different schools and educational levels in future studies. Furthermore, integrating RPG-based learning with emerging technologies such as augmented reality (AR) could enhance students' learning experience and open new opportunities for innovation in mathematics education.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and falsification, double publication and submission, and redundancies, have been completed by the authors.

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Author Contributions

Ulfa Latifa: Conceptualization, writing-original draft, editing, and visualization; **Peti Indrasari:** Writing-original draft, formal analysis, methodology, and editing; **Surya Amami Pramuditya:** Validation, review, and supervision; **Sri Asnawati:** Validation, review, and supervision.

References

Abakah, F., & Brijlall, D. (2024). Misconceptions of mathematical concepts vis-à-vis how they pose as barriers to developing students conceptual understanding. *Gulf Journal of Mathematics*, *16*(2), 81–99. https://doi.org/10.56947/gjom.v16i2.1871

Agusfianuddin, Herman, T., & Turmudi. (2024). Difficulties in mathematical language and representation among elementary school students when solving word problems. *Jurnal Elemen*, *10*(3), 567–581.

Andriani, Y., Suriyana, S., & Novianti, M. (2024). Penerapan game edukasi berbasis kearifan lokal tehadap kemampuan representasi matematika siswa pada materi koordinat kartesius [The use of local wisdom-based educational games to enhance students' mathematical representation ability in learning cartesian coordinates]. *Jurnal Matematika dan Ilmu Pengetahuan Alam*, *4*(2), 21–32.

Anwar, S., & Jasiah, J. (2025). Pengembangan media pembelajaran berbasis game educaplay untuk meningkatkan keaktifan siswa pada mata pelajaran SKI [Development of educaplay-based learning media to increase student engagement in islamic cultural history (SKI) subject]. *Jurnal Budi Pekerti Agama Islam*, *3*(1), 355–373.

Asnawati, S., & Dewi, I. L. K. (2020). Mathematical representation ability using website for learning transformation geometry in a teacher education classroom. *Journal of Physics: Conference Series*, *1511*(1), 012115. https://doi.org/10.1088/1742-6596/1511/1/012115

Asnawati, S., Sanusi, N. M., & Noto, M. S. (2018). Pemecahan masalah matematis berdasarkan kemampuan awal matematis melalui pembelajaran grup investigasi berbantuan geogebra matakuliah geometri analitik [Mathematical problem solving based on students' initial mathematical ability through group investigation learning assisted by geogebra in analytic geometry course]. *UNION: Jurnal Ilmiah Pendidikan Matematika*, *6*(2), 157–166. https://doi.org/10.30738/.v6i2.1950

Asril, R., & Fatmawati, A. (2021). Miskonsepsi siswa smp dalam memahami konsep bangun datar [Junior high school students' misconceptions in understanding the concept of plane figures]. *MEGA: Jurnal Pendidikan Matematika*, *2*(2), 280–288. https://e-journal.unmuhkupang.ac.id/index.php/mega/article/view/496

Azzumar, F., Aniva, T. S., Dewanto, N., & Pramuditya, S. A. (2019). Game virtual reality berbasis open ended [Open-ended virtual reality game]. *Prosiding Seminar*, 296–309. http://fkip-unswagati.ac.id/ejournal/index.php/snpm/article/viewFile/835/381

Choerunnisa, Aminah, N., & Asnawati, S. (2024). Implementasi e-modul kodular berbasis representasi matematis siswa pada materi peluang [Implementation of kodular-based e-module with students' mathematical representation on probability material]. *SIGMA*, *9*(2), 141–148.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, *61*(1–2), 103–131. https://doi.org/10.1007/s10649-006-0400-z

Fatahillah, A. F., & Faradillah, A. (2023). Project-based learning assisted augmented reality in increasing students' mathematical understanding of concepts. *Jurnal Elemen*, *9*(2), 450–

463. https://doi.org/10.29408/jel.v9i2.12703

Febriani, S. W., Sandie, & Darma, Y. (2023). Game edukasi matematika berbantuan RPG maker mv materi bangun datar terhadap kemampuan pemecahan masalah matematis [Mathematics educational game using RPG maker mv on plane geometry to improve students' mathematical problem-solving ability]. *Teorema: Teori dan Riset Matematika*, *8*(1), 172–180. https://doi.org/10.25157/teorema.v8i1.9936

Fikriah, N. A., & Fiangga, S. (2024). Pengembagan media pembelajaran matematika berbasis game edukasi menggunakan RPG maker MZ pada materi sistem persamaan linear [Development of mathematics learning media based on educational games using RPG maker MZ on linear equations system material]. *Prosiding Seminar Nasional Pendidikan dan Pengabdian Kepada Masyarakat (SNPP)*, *3*, 234–250. http://eprints.ukmc.ac.id/1151/1/PROSIDINGSEMINARAVoER9_2017-MARIANURAENI.pdf

Gurmu, F., Tuge, C., & Hunde, A. B. (2024). Effects of geogebra-assisted instructional methods on students' conceptual understanding of geometry. *Cogent Education*, *11*(1), 1-18. https://doi.org/10.1080/2331186X.2024.2379745

Hardianti, S. R., & Effendi, K. N. S. (2021). Analisis kemapuan representasi matematis siswa SMA kelas XI [Analysis of senior high school students' mathematical representation ability in grade XI]. *Jurnal Pembelajaran Matematika Inovatif*, *4*(5), 1093–1104. https://doi.org/10.22460/jpmi.v4i5.1093-1104

Hermawan, D. P., Herumurti, D., & Kuswardayan, I. (2017). Efektivitas Penggunaan game edukasi berjenis puzzle, RPG dan puzzle RPG sebagai sarana belajar matematika [Effectiveness of using educational games of puzzle, RPG, and puzzle RPG types as a medium for learning mathematics]. *JUTI: Jurnal Ilmiah Teknologi Informasi, 15*(2), 195–205. https://doi.org/10.12962/j24068535.v15i2.a663

Hidayat, Y. W., Pramuditya, S. A., & Aminah, N. (2023). Analysis of mathematical representation capabilities in geometry materials assisted by geogebra applications. *IndoMath: Indonesia Mathematics Education*, *6*(1), 35–46. https://doi.org/10.30738/indomath.v6i1.57

Hilmi, Y. (2023). Analisis kemampuan representasi matematis siswa SMP ditinjau dari habits of mind [Analysis of junior high school students' mathematical representation ability viewed from habits of mind]. *J-PiMat: Jurnal Pendidikan Matematika*, *5*(2), 979–988. https://doi.org/10.31932/j-pimat.v5i2.2906

Hutagalung, R. (2017). Peningkatan kemampuan pemahaman konsep matematis siswa melalui pembelajaran guided discovery berbasis budaya Toba di SMP Negeri 1 Tukka [Improving students' mathematical conceptual understanding through Toba culture-based guided discovery learning at SMP Negeri 1 Tukka]. *Journal of Mathematics Education and Science (MES)*, *2*(2), 70–77. https://core.ac.uk/download/pdf/235683985.pdf

Khairani, B. P., Maimunah, & Roza, Y. (2021). Analisis kemampuan pemahaman konsep matematis siswa kelas XI SMA/MA pada materi barisan dan deret [Analysis of grade XI senior high school/islamic senior high school students' conceptual understanding ability on sequences and series]. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *5*(2), 1578–1587.

Kurniadi, E., Sari, N., & Darmawijoyo. (2021). Cognitive processes of using representational form in mathematical modeling based on gender differences. *Jurnal Elemen*, *7*(2), 463–474. https://doi.org/10.29408/jel.v7i2.3627

Laswadi, Handican, R., Arnawa, I. M., & Asmar, A. (2024). Gamifying education: evaluating the role of "corner" video game in improving conceptual understanding and learning interest. *Jurnal Edutech Undikhsa*, *12*(2), 291–301.

Maharani, A., Sudiana, R., & Rahayu, I. (2024). Studi literatur: Evaluasi dampak game edukasi pada prestasi belajar matematika [Literature study: evaluating the impact of educational games on mathematics learning achievement]. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *8*(3), 2386–2398.

Monariska, E., & Komala, E. (2021). Analisi kemampuan representasi mahasiswa pada mata kuliah program liniear [Analysis of students' representation ability in linear programming course]. *Jes-Mat*, *7*(1), 43–58.

Mustangin, M., & Setiawan, Y. E. (2021). Pemahaman konsep mahasiswa semester satu pada mata kuliah trigonometri [First semester students' conceptual understanding in trigonometry course]. *Jurnal Elemen*, *7*(1), 98–116. https://doi.org/10.29408/jel.v7i1.2773

Najuah, N., Sidiq, R., & Sinamora, R. S. (2022). Game edukasi: Strategi dan evaluasi belajar sesuai abad 21 [Educational games: strategies and learning evaluation for the 21st century]. In J. Simarmata (Ed.), *Yayasan Kita Menulis* (1st ed.). Yayasan Kita Menulis.

Prajono, R., Gunarti, D. Y., & Anggo, M. (2022). Analisis kemampuan berpikir kritis matematis peserta didik SMP ditinjau dari self efficacy [Analysis of junior high school students' mathematical critical thinking ability viewed from self-efficacy]. *Mosharafa: Jurnal Pendidikan Matematika*, *11*(1), 143–154. https://doi.org/10.31980/mosharafa.v11i1.694

Pramuditya, S. A., Noto, M. S., & Azzumar, F. (2022). Characteristics of students' mathematical problem solving abilities in open-ended-based virtual reality game learning. *Infinity Journal*, *11*(2), 255–272. https://doi.org/10.22460/infinity.v11i2.p255-272

Pramuditya, S. A., Noto, M. S., & Handayani, V. D. (2021). Desain didaktis konteks fabel berbasis pemahaman matematis siswa pada materi aljabar [Didactic design using fable context based on students' mathematical understanding in algebra material]. *Jurnal Elemen*, *7*(1), 68–83. https://doi.org/10.29408/jel.v7i1.2730

Pramuditya, S. A., Noto, M. S., & Purwono, H. (2018a). Desain game edukasi berbasis android pada materi logika matematika [Design of android-based educational game on mathematical logic material]. *JNPM (Jurnal Nasional Pendidikan Matematika)*, *2*(2), 165–179. https://doi.org/10.33603/jnpm.v2i2.919

Pramuditya, S. A., Noto, M. S., & Syaefullah, D. (2017). Game edukasi RPG matematika [Mathematics RPG educational game]. *Eduma : Mathematics Education Learning and Teaching*, *6*(1), 77–84. https://doi.org/10.24235/eduma.v6i1.1701

Pramuditya, S. A., Noto, M. S., & Syaefullah, D. (2018b). The educational game design on relation and function materials. *Journal of Physics: Conference Series*, *1013*(1), 012138. https://doi.org/10.1088/1742-6596/1013/1/012138

Putra, M. (2023). Desain game edukasi berbasis sistem (science, technology, engineering and mathematics) berbantuan RPG maker MV untuk mendukung kemampuan berpikir kreatif peserta didik pada materi bangun ruang sisi datar kelas VIII SMP [Design of system-based (STEM) educational game assisted by RPG maker MV to support students' creative thinking ability on solid figures material for grade VIII junior high school]. *At-Tawassuth: Jurnal Ekonomi Islam, 8*(1), 1-212.

Rahmawati, L., Romansyah, K., Rohayani, S., & Asnawati, S. (2021). Perbedaan kemampuan representasi matematis ditinjau dari jenis kelamin [Differences in mathematical representation ability reviewed from gender]. *Jurnal Matematika Thales (JMT)*, *3*(1), 1–8.

Rhamadhan, M. R. A., & Haerudin, H. (2024). Pengembangan media game edukasi cerita rakyat berjudul wiro sableng menggunakan RPG Maker MV [Development of folklore educational game titled wiro sableng using RPG maker MV]. *OKTAL: Jurnal Ilmu Komputer dan Science*, *3*(3), 754–765.

Sweller, J. (2011). Cognitive load theory. in *psychology of learning and motivation - advances in research and theory* (Vol. 55). Elsevier Inc. https://doi.org/10.1016/B978-0-12-

387691-1.00002-8

The National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. in t. n. c. of t. of mathematics (Ed.), *NCTM Publications* (1st ed., Vol. 43, Issue 5). Library of Congress Cataloguing-in-Publicarion. https://doi.org/10.5951/mt.43.5.0224

Tijani, B. E. (2025). Impact of open inquiry instructional strategy on secondary school students' academic achievement and conceptual knowledge in chemistry across genders in Osun State, Nigeria. *African Journal of Spread Corporation*, *14*(1), 120–141.

Vygotsky, L. (1978). Mind in society: The development of higher psychological processes. *Harvard University Press*.

Zebua, N., Malik, P. F. P., Al-Hilmiyah, N. A.-A., Zebua, E. N. K., Pebrianti, P. E., Sari, M. S., & Rudiyanto, R. (2024). Analisis penggunaan metode gamifikasi untuk meningkatkan motivasi dan hasil belajar siswa pada mata pelajaran IPA-Biologi [Analysis of gamification method use to increase students' motivation and learning outcomes in natural science–biology subject]. *Jurnal Cakrawala Pendidikan dan Biologi*, *1*(4), 183–188.