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Exploring the Influence of Science Lessons Through Text-Based Explanations and Game-Based Explanations Mixed With A Socio-Scientific Approach on Issues on Students Rational Thinking Ability and Mistaken Understanding

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ABSTRACT In both private and public education, several institutions may use game-based explanations. However, it does not rule out the possibility that most educational institutions use text-based explanations, which makes students tend to get bored because they only have to read and listen, so another alternative is needed: game-based explanations that can stimulate students' enthusiasm. Students improve their rational thinking abilities by adding a socio-scientific approach to reduce student misunderstandings. The method used in this research is a quantitative approach with a quasi-experimental design type of research. Hence, the research uses control and experimental classes for evaluation. The sample used was 29 students for the control class and 27 students for the experimental class. Based on the results obtained on rational thinking, the effect of conventions on rational thinking is 0.19, so there is no significant difference, and the post-test is 0.38, so there is a significant difference. In contrast, the effect obtained on the misunderstanding effect of conventions is 0.03. There is also no significant difference, but based on the average results of the experimental class, it is relatively superior to the control because the average of the experimental class is 83 and of the control class is 66, so game-based explanations are quite more influential than text-based explanations. This study offers insights into integrating multiple teaching methods to improve students' rational thinking skills, reduce misunderstandings, and make science learning more engaging.

Keywords: Game-based explanation, Text-based explanation, Socio-scientific issue, Rational thinking

1. INTRODUCTION

In public and private education, game learning has been implemented and gained recognition as a practical learning medium used in educational institutions. Students cannot be separated from games; often, games are only used as entertainment, but behind that, games can be used as a means of learning so that learning is not monotonous, which can cause students to get bored (Widiningsih & Abdi, 2021; Rahaju & Hartono, 2017), such as learning methods that use games, such as the Teams Games Tournament (TGT) method, and quizzes using the Quiziz website. Learning combined with games further increases students' ability to participate in learning. Learning that uses mixed game-based explanations has yet to be widely developed and used by teachers (Kumala Dewi & Suminten, 2020). However, many educators have recently started to develop educational games because they feel that the presence of games in learning will make students more enthusiastic and happy to participate in learning (V. D. Astuti et al., 2021; Robertson, 2013). Learning by providing digital (modern) and traditional games is used as a means of entertainment and training students to improve their cognitive abilities and critical thinking skills (Chang & Yeh, 2021; Reynaldo et al., 2021).

Disadvantages of implementing mixed game-based learning include the fact that it requires a relatively large amount of time and additional tools and media so that learning becomes exciting and students become enthusiastic about participating (Oktavia, 2022). Apart from that, not all teachers who teach are proficient with technology, which is why game-based learning can only be implemented by teachers who are proficient with technology, even though teachers should create a fun and

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meaningful learning atmosphere (Fakhrurrazi, 2018; Fatimah & Santiana, 2017; Sadari, 2019). This means that modern and digital game-based explanations cannot be fully implemented, which is the cause of low cognitive abilities in science teaching (Kulgemeyer & Wittwer, 2023). Based on the data obtained by researchers shows that the development of games as a means of learning media has a positive impact, namely that it can improve students' critical thinking skills (Chang & Yeh, 2021; McGill & Bax, 2005). The hypothesis shows that if game-based learning is implemented, there will be an increase in students' abilities. The Monopoly game is a traditional game that has been implemented to improve students' analytical skills and has been proven to be successful (Rahaju & Heriyawati, 2020; Ulfaeni, 2017)and the presence of games using digital games also has a positive impact, namely increasing cognitive abilities, critical thinking abilities and the ability to increase motivation (Chang & Yeh, 2021; Kumala Dewi & Suminten, 2020). Apart from that, by conducting game-based learning, there is an approach that can be used to improve students' analytical skills, namely the Socio-scientific Issue (SSI) approach (Berne, 2014), which can be used to measure rational thinking abilities. The Educational Policies Commission mentions several indicators of the ability to reason, including remembering, imagining, grouping, generalizing, comparing, evaluating, analyzing, synthesizing, deducing, and making conclusions (Nurachman & Irawan, 2020). Research on rational thinking abilities is essential as it helps us understand how individuals make decisions, solve problems, and evaluate information logically.

On the other hand, mistaken understanding refers to errors or misconceptions in reasoning that can lead to incorrect conclusions. Studying mistaken understanding is crucial as it sheds light on common cognitive biases and fallacies that can impact decision-making and problem-solving processes. Previous research has explored various aspects of rational thinking abilities and mistaken understanding. For example, Zayyadi et al. (2022) discuss the transformation of thought from rational to Sufistic trends, Jordan et al. (2023) focus on promoting systems thinking through perspective-taking, and Ashari et al. (2022) analyze students' critical thinking skills in determining plane figure properties. These studies contribute to our understanding of how rational thinking abilities and mistaken understanding influence decision-making and problem-solving processes. This shows a difference between learning methods that only use written explanations, causing students to be less active and even get bored, compared to game-based learning, which can make students active and interested in participating in learning (Durin et al., 2019; Nur'Aini, 2018).

As game-based learning has become an increasingly established medium in science teaching, the weaknesses of game-based learning should be examined as closely as possible to its potential, and this research contributes precisely to this goal (Hafiyya & Hadi, 2023; Sadari, 2019). The current experimental study determines whether mixed game-based learning with the SSI approach can improve rational thinking abilities (Rachmawati & Diningsih, 2021; Rahmawati et al., 2018). It also determines knowledge attainment in phenomenal cases regarding material classification material. The combination of Monopoly and quiz games in science teaching can help teachers use which method to use in order to attract students' attention (Allate, 2024; Chang & Yeh, 2021; Matsekoleng et al., 2022).

Learners with low prior knowledge are often considered the primary target group for general instructional explanations (Sofiana & Wibowo, 2019). Based on the theoretical considerations mentioned above, we identified the aim of this research regarding mixed game learning with a socio-scientific approach to science explanations compared to text-based explanations with a socio-scientific approach for students with low initial knowledge based on the pretest results that have been given to students which shows that the pretest results of all students in control class and experimental classes are significantly below average.

Based on evidence from previous research, it is clear that mixed game-based learning has advantages in terms of achievement (Chang & Yeh, 2021; Cicchino, 2015). Based on previous research, students prefer to use a mixed game system rather than written explanations (Sindi et al., 2023). The first hypothesis reminds us that the media influences a person's perception of an explanation. Written explanations that look like textbook entries give the impression of being more reliable and convincing, which also causes students to overestimate their knowledge acquisition (Kulgemeyer et al., 2022a; Sunarno, 2015).

Researchers use mixed learning through the SSI approach, an innovation with material adapted to schools and booklets with the SSI approach (Berne, 2014). The material that will be used is about the classification of matter. The explanation directly offers learning progress from game-based learning, especially virtual-based learning. For conceptual knowledge, which involves the transfer of newly discovered ideas to other examples that are immediately included in rationalization, more energetic mastery followed by acquiring knowledge of obligations may be essential. Therefore, the research addresses the potential of rational thinking and misunderstanding as an exciting research study. This research aims to determine whether learning media through text-based explanations affects students' rational thinking abilities compared to game-based explanations and whether learning through text-based explanations with a Socio-scientific issue approach can influence students' misunderstandings compared to game-based explanations.

1.1 Literature Review

Science Learning through Text-Based Explanations

Text-based explanations can also be written explanations that use print as an outcome and are handed over to students as teaching media in schools. Text-based explanations are often used in education. This media should not be used in every situation but should be adapted to the situation and conditions. Text-based explanation media in books or printouts convey learning messages that contain text (readings) and supporting illustrations (Sunarno, 2015).

Science learning through text-based explanations utilizes printed media in a programmed manner. This is one of the teaching delivery systems using printed media containing scientific materials. It allows students to learn individually according to their abilities and learning opportunities and obtain results that are within their abilities (Siregar et al., 2020; Sofiana & Wibowo, 2019).

Educational research has been interested in science learning through text-based explanations. Novianti et al. (2023) analyzed students' errors in understanding energy concepts using Conceptual Change Text (CCT)-based learning. This highlights the importance of effective text-based learning strategies in science education. Furthermore, Zabadi (2023) explored the role of the Indonesian language in the 2013 Curriculum through text-based language learning. This research emphasizes the significance of incorporating language learning strategies within science education to enhance comprehension and communication.

Moreover, Septaria and Fatharani (2022) introduced an alternative science learning module based on manga and webtoon formats, catering to Indonesian students' reading preferences. This innovative approach demonstrates the potential of using engaging text-based materials to stimulate students' interest in science learning. Figure 1 shows text-based explanation.

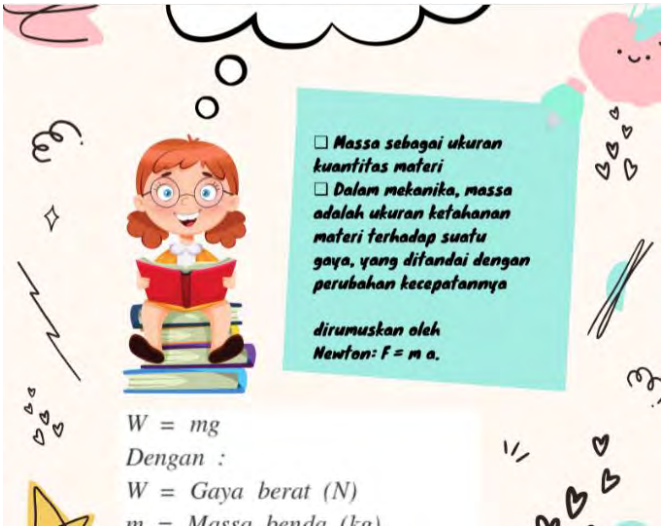

Figure 1 Text-based explanation

Science Learning through Games

Game-based learning that has been developed is then used in education to involve students in improving achievement in an educational process. Two types of games can be applied when learning, namely games that are commonly used, namely traditional games and technology. Students are satisfied with game-based learning, which improves and develops students' abilities apart from entertainment in learning activities (Chang & Yeh, 2021; Coco et al., 2001). Games in learning also contain instructions on how to use the games that will be played by students accompanied by the teacher (Oktavia, 2022; Yıldız & Zengin, 2021).

Cicchino (2015) revealed that mobile applications have recently attracted attention, are characterized by direct interaction between students and teachers, are easy to use, have proven effective, and can improve students' critical thinking abilities. Considering the advantages of traditional game-based and mobile learning, this research tries to integrate these two types of learning to improve critical thinking learning. When each game has passed a challenge, it will slowly pass another challenge, namely a challenge at a higher level than the previous one. This is an opportunity to develop learning media that have more potential to be applied when teaching, which will positively impact students, namely that they tend to avoid getting bored because the learning methods used by teachers are monotonous. Chang and Yeh (2021) revealed that game-based mixed learning can help teachers develop knowledge within themselves through an approach that is then transferred to traditional and modern games. Kumala Dewi and Suminten (2020) revealed that game-based mixed learning is felt to have a significant impact and positive influence on students. This shows that game-based learning is more effective than lecture- and assignment-based learning (Li & Tsai, 2013).

As time goes by, technology is becoming more sophisticated day by day; as time goes by, the era has entered the 5.0 era, so there is a need for rapid technological development. As technology develops, we must quickly keep up with current developments as educators, like digital games that contain games that can be applied as learning media (Nafrin & Hudaidah (2021). It reminds us to develop distance learning during the COVID-19 pandemic, which might be one of the solutions to the new COVID-19 development that is rumored to be occurring. Appearing in 2023, namely the Eris variant of the coronavirus virus has entered several regions in Indonesia, such as Bali, Jakarta, and Java. In the West, East Java, and North Sumatra regions, parole variants of the virus have been detected in several countries, namely Denmark, England, the United States, Israel, and South Africa. Game-based learning, mainly digital, is hoped to

become an interactive learning medium between students and teachers during the pandemic (Jediut et al., 2021).

One of his research topics is mixed game learning design with a Socio-scientific Issue approach to improving rational thinking skills. Learning design mainly lies in the games that will be applied to students, both traditional and digital games (Chang & Yeh, 2021).

Rachmawati and Diningsih (2021) revealed that a socio-scientific approach to a problem could improve reasoning abilities. In addition, R. Astuti et al. (2021) revealed that using a socio-scientific approach to problems can improve thinking abilities, namely the ability to think clearly and reason. These findings indicate that research on socio-scientific approaches to problems generally focuses on rational abilities.

Septanto (2014) conducted research whose results showed that working on questions was easier using multimedia than on paper because by using multimedia, the time used was more effective. The grades came out immediately without making corrections as was done on paper. Game-based learning was developed using the SSI approach, which contains controversial phenomena; in learning, digital games can be used to measure students' cognitive abilities. In the student learning design that will be implemented, there are several instructions that students must follow before using it. Adaptation can be made by 1) understanding the steps that will be used when using traditional or digital learning and 2) the level of problem-solving they may experience. By students, 3) mastery of the material, and 4) controversial phenomena. Adapting to the learning design is easy because, in traditional games, most students are familiar with the game that will be implemented.

In contrast, in digital games, there is a need for guidance so that students can know how to answer the questions in multimedia. Based on several researchers, the average shows that blended learning positively impacts students. For learning with the SSI approach, students are shown an event related to diffusion material. The SSI approach is expected to improve students' abilities, namely the ability to analyze. The blending-based learning design is also expected to improve rational thinking skills (Berne, 2014; Rachmawati & Diningsih, 2021). The ability to reason can be improved by changing less effective learning methods, such as learning with text-based explanations, which can accommodate differences in students' ways of learning, challenging students' creativity and active involvement in learning activities (Zahro & Hadi, 2022). Rational thinking skills can be achieved if there is special treatment, namely improving rational thinking skills using the blended game learning method with a socio-scientific issue approach (Pratiwi & Januardi, 2019). The title used when researching was "Increasing Students' Rational Thinking Ability Through Blended Learning with Learning Independence Moderator Variables," which has gone through 2 cycles, and the results prove that there has been an increase of 75% (Pratiwi & Januardi, 2019).

Misunderstanding

In education, there is the ability to understand, where the ability to understand is a person's ability to understand or comprehend something. After that, something is known and remembered. However, not all students understand what the teacher teaches. So, misunderstandings arise among students, which is often called misunderstanding. Misunderstanding is the latest research that has not done any research on misunderstanding, so there are no references to support this misunderstanding. Misunderstanding is the inability of students to understand the explanation given by the teacher, so students experience confusion regarding the material that has been presented.

Misunderstanding is a common occurrence in the field of science, including different materials science concepts. Of the 700 exams regarding misguided judgment, about 300 are centered on mechanics, and about 159 are on electrical power. Generally, 70 exams are on the properties of heat, optics, and materials, about 35 are on land and space, and others guarantee contemporary science materials (Trowbridge & Wandersee, 1994). The characteristics of the concept itself, such as abstractness and complexity, are the causes of most student misconceptions (Soeharto et al., 2019). This complexity can be seen from the relationship between concepts because studying materials science is inseparable from reality, concepts, laws, and hypotheses. The essence of material science as a guide is related to miracles, speculation, perception, estimation, examination, and distribution, and the essence of material science is an attitude that envelops the state of mind that originates from consideration (Herliandry et al., 2021).

Misunderstanding in education can hinder learning outcomes and conceptual development. Rozaki et al. (2023) investigated code-switching as a bridge of classroom misunderstanding, highlighting its impact on communication and comprehension. Additionally, Nikmah et al. (2022) explored misconceptions about photosynthesis and plant respiration among prospective science teachers, emphasizing the importance of addressing and correcting misunderstandings to enhance teaching effectiveness. Furthermore, Pozzer (2022) discussed the significance of addressing misunderstandings in science education from a human rights-centered perspective to promote informed decision-making and social change.

Socio-scientific Issue Approach

Socio-scientific Issues, commonly called SSI, is an approach whose learning strategy presents scientific material in the context of social issues that involve a moral and ethical component (Rachmawati & Diningsih, 2021). So in learning practice, the socio-scientific approach to

problems, according to Zeidler in the journal (Sofiana & Wibowo, 2019) SSI is an approach that has the aim of stimulating moral, ethical, and intellectual development, as well as having an awareness of the relationship between science and social life, which relate directly or indirectly to human life. Therefore, using this approach indirectly provides students with an understanding that everything in the universe is related to science. Rahmawati et al. (2018) said that learning uses a socio-scientific issue approach as a learning approach; there are several definitions:

The socio-scientific issues approach is an approach that 1) aims to stimulate (a) morals, (b) ethics, and (c) intellectuals and 2) has an awareness of scientific matters (c) directly, (d) or indirectly.

This is almost similar to research conducted by (Siska et al., 2020). There are several criteria for taking a socio-scientific approach to a problem. There are several criteria for raising issues that will be used, including 1) Has a scientific basis, 2) involves forming opinions and making choices at the individual and community level, 3) is often highlighted by the media, 4) there is a lack of complete information, 5) leads to local, national and global dimensions related to political and social frameworks, 6) involving ethical values and considerations, 7) requiring an understanding of various possibilities and risks related to events in the surrounding environment. Researchers found challenges for students if they used a socio-scientific approach to a problem. These challenges include sharing ideas, knowledge, and values based on social issues presented in learning. Then, analyze whether errors will occur, such as if there is no relationship between the phenomenon raised and scientific concepts. SSI uses science in a structured manner, which allows students to be actively involved in debate, dialogue, and discussion. The SSI approach also provides an ideal context that seeks to involve students in making decisions related to social issues that contain moral implications in which there is a scientific context. SSI-based learning issues are both conceptually and procedurally open-ended and allow for rational solutions that can influence various aspects, including cultural identity, politics, ethics, and economics. Providing evidence of something happening in SSI learning can encourage students to understand the role of science in the real world through rational thinking.

Rational Thinking Ability

Rational thinking is one of the critical thinking skills in learning natural sciences because science is a scientific discipline based on the scientific method. This is in line with the opinion of Hendrayana (2017). The emphasis given to teaching science learning is on thinking skills. Students' development in understanding learning can be stimulated through the ability to think and to know how to solve a given problem. One of the thinking abilities is the ability to reason. Rational thinking is the ability to collect and then combine knowledge, empirical evidence, critical thinking, and logic that can be used to understand phenomenal natural events and explain various phenomena of the universe. According to Susanto et al. (2019), there are several reasons why rational thinking skills are essential in science learning: (1) Science learning involves a process of discovery and exploration to understand the situation and conditions of the natural world. This rational thinking can help students to develop hypotheses (temporary conjectures), design trials (experiments), and analyze data logically, thus enabling students to make relevant scientific discoveries. (2) In understanding scientific concepts in science, rational thinking can help improve the understanding obtained. Students can connect the ideas they find with empirical evidence and identify patterns in observational data (3). In science learning, things that involve complex problem-solving are often discovered. Likewise, rational thinking allows students to formulate problems, identify solutions with various alternatives, and analyze the implications of the solutions obtained. (4) In the world of education, which over time is increasingly flooded with information, especially natural knowledge, students need to evaluate the sources of information they obtain and be able to distinguish between legitimate science and pseudoscience. This rational thinking plays a role in developing critical thinking skills to sort out reliable (trustworthy) information, (5) Making informed and accountable decisions. One way of making decisions can be assisted by reasoning through students making decisions based on scientific evidence, not just assumptions or prejudices. This is an essential context in science learning because scientific decisions often significantly impact society and the environment. (6) Development of critical skills: Rational thinking plays a role in students developing critical skills such as analysis, synthesis, and evaluation. These skills function in various aspects of life, not only in the context of science learning. (7) Abilities that can contribute to both social and natural sciences: In this case, rational thinking is one of the keys to participating in the scientific community. Students who can reason can contribute to research, policy-making, and innovative development. With this, it can be proven that rational thinking is an essential competency for understanding, participating, and analyzing effectively in science learning because it allows students to develop a greater understanding of the natural world, which can encourage progress in scientific knowledge.

Rational thinking is crucial in developing students' scientific reasoning and problem-solving skills in science education (Sholikhah et al., 2023). Students can critically evaluate information and make informed decisions by fostering rational thinking abilities. Integrating rational thinking skills into science education aligns to enhance students' problem-solving capabilities and logical reasoning (Putri & Fadly, 2022). Through rational thinking, it is hoped that students will be able to criticize everything and

become more scientifically logical by the characteristics of science learning. This follows the principles of science learning, which seeks to help students solve problems in everyday life so that rational thinking can be developed through science learning.

Before starting the research, the researcher formulated the problem and created a hypothesis to answer the objectives of this research.

1) Does learning through text-based explanations with a Socio-scientific issue approach influence students' rational thinking abilities more than game-based explanations?

2) Can learning through text-based explanations with a Socio-scientific issue approach influence students' misunderstandings rather than game-based explanations?

Because, as explained above, evidence from previous studies is clear that it can improve critical thinking skills, it is impossible to predict which media will have the advantage in achieving rational thinking. Therefore, in an attempt to answer Question 1, we tested the following hypothesis:

Hypothesis 1: Game media produces achievements that lead to more excellent knowledge of rational thinking skills compared to text-based explanations. Alternative hypothesis 1a: Explanatory text-based explanations given by the teacher result in greater attainment of rational thinking knowledge compared to mixed game learning. Alternative hypothesis 1b: Text-based explanation and blended learning produce the same rational thinking achievements. 1c Alternative hypothesis: Game-based explanations given by the teacher result in greater attainment of rational skills knowledge than text-based explanations.

As explained above, rational thinking is when a person can draw conclusions that have a basis and can be accounted for and supported by logic, rules, and data. Similar to Research Question 1, there is clear evidence regarding Research Question 2. Therefore, the following hypotheses regarding Research Question 2 will be tested:

Hypothesis 2: Mixed game-based explanations are more likely to lead to misunderstandings than text-based explanations. Alternative hypothesis 2a: Mixed game-based explanations cannot improve rational thinking abilities. Alternative hypothesis 2b: Game-based explanations are the same as other learning. 2c: Mixed game-based explanations produce fewer comprehension errors than text-based explanations.

This research was conducted on science subjects at the SMP/MTs level at an educational institution in Ponorogo. This subject is mandatory for all students. Experiments were carried out before the classification of materials was introduced. Students are required to participate.

2. METHOD

The method used in this research is quantitative research methods. Quantitative methods are research approaches that use data that can be measured numerically to collect information, analyze relationships between variables, and produce generalizations that can be tested. This method uses statistical techniques to process data and support findings with numbers and facts. Thus, quantitative methods provide a systematic and objective approach to the research process (Ghafar, 2023; Ghanad, 2023).

2.1 Research Subject and Design

The sample participants were around 56 students using random sampling techniques from grade 7, so 56 students were remaining as samples in this study. The participants were registered in the school under study by looking at student attendance. The sample used for this research was 56 students from class 7. Of the 56 participants, 29 students were used as a control class, namely class 7A, and 27 students from class 7 as an experimental class, namely class 7B with considerations for grouping research subjects into experimental and control classes include the need to compare the effects of the treatment or intervention given to the experimental group with normal conditions or conditions without treatment in the control group. Thus, the study can evaluate the effectiveness of the intervention carried out. The material presented by the researcher had never been given at school. Therefore, they are expected to have a low prior knowledge of physics comparable to high school students. Therefore, this pattern is a sample that is easy to take and is worthy of exploration because its characteristics make it different from other students. Knowledge of 0 material is expected not significantly to influence the variables determined from this research (Kulgemeyer et al., 2022b).

2.2 Material: Text-Based Explanation and Game-Based Explanation

For this test, we decided to use a Monopoly type of game. This game is designed following a framework created by systematic researchers regarding educational explanation standards related to the focus on science education. This framework includes seven factors that influence the effectiveness of the game: (1) image structure, (2) adaptation to the recipient group, (3) use of appropriate aids to obtain editions, (4) minimal clarification that avoids deviation and keeping cognitive load low, (5) highlighting the reasoning itself that is relevant to the student and other components that may be particularly relevant, (6) assigning responsibility for learning after the game, and (7) focusing on rational concepts (Rahaju & Hartono, 2017). The instructions given by the trainer are listened to and understood, and they are on how to utilize Monopoly Recreation, which is used as a learning medium. Then, the text-based explanation uses media as a printed booklet

whose introduction is a phenomenon as an introduction to material classification material.

Both learning media have used a socio-scientific issue approach. In the booklet media, before leading to the printed booklet, the SSI approach is only shown as an introduction to material such as showing one of the natural disasters in Indonesia, which is still related to material classification material such as flash floods. The approach outlined in the Monopoly game is to show pictures of disasters within Indonesia and outside Indonesia. The approach outlined in the learning media stimulates students' thinking, which makes learning more meaningful and trains students to solve problems rationally (Sofiana & Wibowo, 2019; Rahmawati et al., 2018).

The monopoly game can be played by throwing a dice that displays a number on the dice as it travels from one location to another. When they arrive at a particular area, students are given a card containing questions, which they are then asked to analyze. The events obtained include any scientific concepts used as a basis and explanations of their relationships. When all students have received their respective parts, ask them to present what they got. This can be useful for students with genius thoughts but do not dare to express them, so this media helps them share as much knowledge as possible. The presentation begins with the group throwing the dice for the first time, and a discussion occurs regarding whether what is presented is by the material provided or not. The learning design in this research is a socio-scientific issue approach with game-based learning to improve rational thinking skills. All experimental instruction was used through 7th grade, and researchers taught science subjects. Instructions for using the game can be seen in Figure 1 as instructions for using the Monopoly game, and Figure 2 is a display of the game between Monopoly and Blokerz. Figure 3 shows Game-Based Explanation that Combines Games Between Monopoly and Blockerz (Digital Games)

The aim of acquiring technological knowledge is to look at problems related to technological knowledge, simple technological standards, the importance of statistical technology, and the uses and usefulness of generation that can be used as knowledge to know. Currently, rational thinking skills are also recommended. The materials are adjusted to what is obtained through samples. However, the teacher reorganized and infused the material with new articles, examples, and current affairs. Learning outcomes are evaluated through post-tests—the type and design of post-test questions in the form of material that has been presented.

Table 1 Examples of misunderstanding questions using socio-emotional questions

On Monday, Rama found trash scattered around. This trash was a heterogeneous mixture because it was mixed with other materials. He remembered that cleanliness is part of faith. The action that Rama should have taken was….
Dispose of rubbish according to the type of rubbish in the rubbish bin
Dispose of rubbish properly in the rubbish bin
Collect rubbish and throw it in the trash
Collect trash, then sort it and throw it in the trash

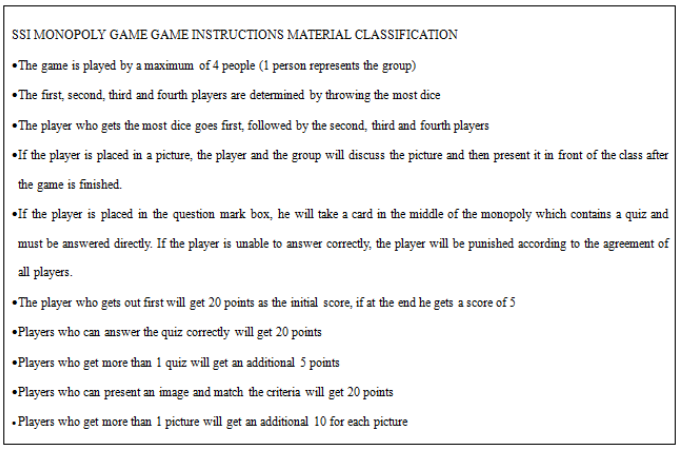

Figure 2 Instructions for using the SSI Monopoly game

a. Monopoly game education

b. Educational Blockerz game

Figure 3 The game-based explanation that combines games between Monopoly and Blockerz (digital games)

2.3 Data Analysis

Researchers used several instruments; we measured (1) an educational game usage experience questionnaire before treatment, (2) rational thinking, which is part of the explanation (pretest and post-test), and (3) learning reflection (post-test). (Just test).

2.4 Control variables

The core aspect of the control variable is the final learning score on the material classification material. This value is a good indicator of a person's success in the academic field after studying, as stated (Sa'idah & Annajih, 2020), and therefore reflects academic skills helpful in learning both text-based and game-based explanations. This should be comparable between groups. We also measured participants' gender and academic self-concept in physics using a 5-point Likert scale: not good, fair, reasonable, and very good. Examples of socioemotional questions can be seen in Table 1.

Participants are generally asked to form groups (mainly consisting of five to seven students in each group) in the first week of the semester. Then, each group listened to Monopoly game instructions. Throwing the dice determines the steps given to students to determine the topic they get. Meanwhile, participants were asked to read other online articles regarding the topics obtained and then relate them to scientific concepts.

After that, each group explained their presentation activities. The group that has found the concept and presented it correctly will get 10 points as the starting point for the game. By presenting the Monopoly game, students will know the results and data obtained by students. Presentation activities are activities that are used as a means of sharing knowledge.

After the Monopoly game, continue understanding what has been conveyed to answer the questions that will be tested on students as a measure of students' cognitive abilities. The exam is given via a quiz link with multiple-choice questions. Experimental learning lasted for two weeks. The process of teaching and learning activities is divided into two components, namely concept delivery and discussion. These two components cover important things in rational thinking that can guarantee learning outcomes from the subject matter. During the experimental learning, a Monopoly game was provided in the classroom to provide an opportunity to understand the description of the Monopoly game. However, this learning-based monopoly game is only implemented according to the needs of each teacher. Students are asked to bring their smartphones to class when entering science lessons. During learning, all students have their smartphones with internet access. They can use the instructor's desktop if the Internet is down or students prefer not to use their devices.

Study Overview, Procedures, and Research Procedure

Testing time is limited to 45 minutes. After a brief introduction, students were divided into text-based explanation groups and groups using random game learning. After that, a pretest was given in the form of a questionnaire that was distributed about game learning experiences, questions about misunderstanding, and the ability to reason about the classification of matter. Then, they worked with media according to categorized experimental conditions. They took the test individually and could not surf the Internet or use any material other than the media provided.

The pretest and post-test instruments were the same between the two groups, except for arranging several statements on a scale of perceived explanation quality according to each medium. The effect convention obtained is at a medium level, which means that this research can still change (e.g., ' Was the game well executed?' versus whether the text was well executed). Both groups were tested directly in predetermined groups.

Researchers analyzed the learning results of both groups (hypothesis 1 and alternative). Researchers used the t-test and one-way ANOVA to compare the results of the pretest and post-test with the Socio Scientific Issue approach through scores on the rational thinking ability and misunderstanding scales. Next, we compared the correlation between rational thinking ability scores and Misunderstanding scores for each experimental condition to determine whether game-based learning can improve rational thinking ability. If hypothesis 2 is correct, the researcher estimates a significant difference between the experimental conditions regarding the achievement scores obtained. In addition, text-based explanations are expected to show no correlation with mixed game-based learning. The research steps can be seen in Figure 4.

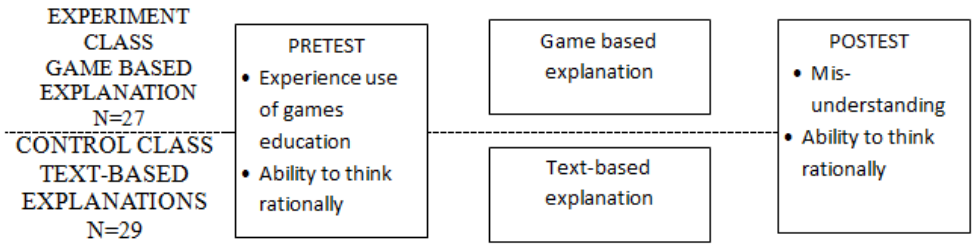

Figure 4 Research procedure

3. RESULT

3.1 Rational Thinking Ability

Descriptive statistics of study variables, including control variables, have been used previously. This can be seen in Table 3. Using the t-test, we found no significant differences between groups regarding the control variables (Table 3). The results of the t-test based on two groups, the control group and the experimental group, produced results that were used to determine the strength of the existing sample size, namely ($\chi 2(1) = 0.05$, $p = 0.31$) so that the results obtained based on the p-value showed that the sample size used has weak power because p based on the sample power test is less than 0.50, for the pretest normality test in the experimental class and control class with Monte Carlo measurements as in Table 2 shows that the data used is usually distributed in both the control class and the experimental class. This is a prerequisite for comparing groups.

Table 2 Normality Test with Monte Carlo

		Pre-exp	Post-exp	Pre-fraud	Post-con
N		27	27	29	29
Normal Parameters, b	Means	42.48	82.74	44.90	66.62
	Std. Deviation	11.557	8.132	9.593	16.847
Asymp. Signature. (2-tail)		.012c	.100c	.001c	.076c
Monte Carlo sign. (2-tail)	signature.	.245d	.504d	.108d	.456d

Based on the normality test in the table above. This data shows a normal distribution because it has an assymp.sig value of more than 0.05. When we find out the data is normally distributed, the next step is to conduct a pretest and post-test on the control and experimental classes.

Research Question 1: Do mixed game-based explanations improve rational thinking skills compared to text-based explanations?

Table 3 Descriptive statistics of research variables

	Game Class M(SD)	Text Class M(SD)	Reach
Rational Thinking Ability (Pre)	0.42 (0.12)	0.45 (0.10)	0-1
Rational Thinking Ability (Post)	0.83 (0.08)	0.66 (0.12)	0-1
Misunderstanding	2.83 (0.81)	2.90 (0.80)	1-4
Educational game experience questionnaire	2.88 (0.72)	2.80 (0.)	1-4

Table 3 shows a comparison of these scales. Learning gains (ANCOVA of post-test results adjusted for pretest scores) showed a difference ($F(1,54) = 1.09$, $p = 0.03$, partial $\eta 2 = 0.011$). This result is in line with alternative hypothesis 1c

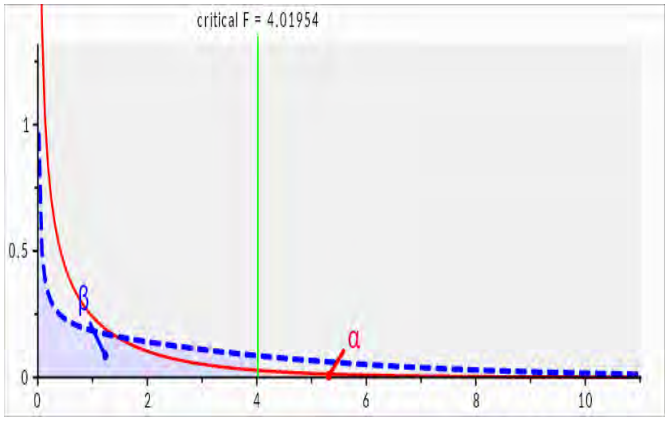

Figure 5 ANOVA pretest control class and experimental class with The sample size (X-axis) indicates the number of observations or participants in the study. At the same time, statistical power (Y-axis) reflects the probability of detecting an actual effect if it exists.

Figure 5 shows ANOVA pretest control class and experimental class. The graph shows the results of the pretest ANOVA ($F(1,54)=4.01$, $p=0.19$), interpreting the statistical calculations used. Suppose p, the convention effect in G*Power, is less than 0.30. In that case, the difference is significant because the p obtained is less than 0.30. In the pretest, both the control and experimental classes did not show a significant difference.

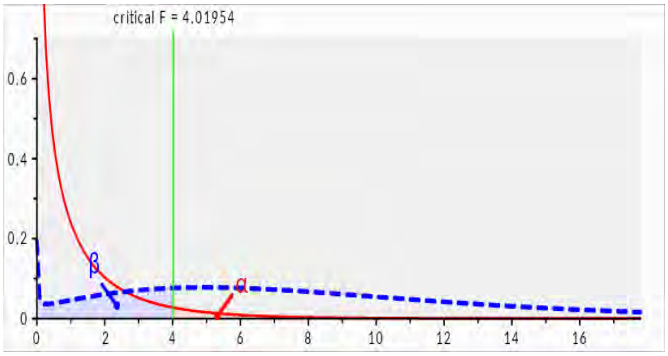

Figure 6 ANOVA post-test control class and experimental class

Figure 6 shows Anova post-test control class and experimental class. Thus, there is a significant difference between the experimental and control groups because the effect convention of the post-test is 0.38. This is proven if the effect size is more than 0.30, then there is a significant difference between the control group and the experimental group. This is in line with hypothesis 1c, namely, by using game-based explanations, students can improve their rational thinking abilities. Apart from that, from the class average, the average learning outcomes for rational

thinking skills are higher than the group that used text-based explanations.

3.2 Misunderstanding

Research question 2: Does game-mixed learning with the SSI approach cause more misunderstandings than text-based explanations?

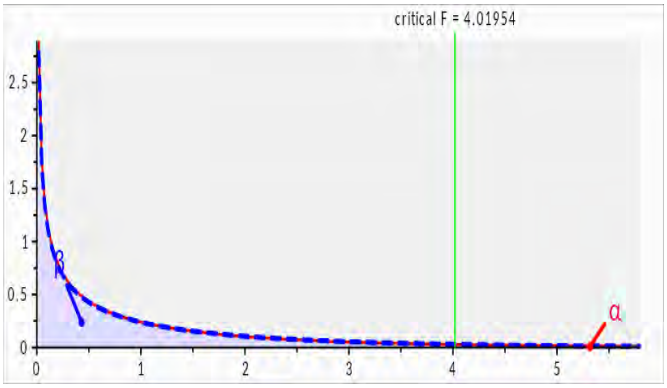

Figure 7 Misconceptions of post-test ANOVA

Figure 7 shows Misunderstanding of Post-test Anova. The graph shows the results of the misunderstanding ANOVA post-test, which shows ($F(1,54)=4.01$, $p=0.03$). There is no significant difference because the conventional effect size value obtained in the data is smaller. Of 0.03 so, the post-test is good. The control class and experimental class did not show significant differences. In other words, the misunderstanding obtained between the control and experimental classes did not show a significant difference; this is in accordance with hypothesis 2b. To find out more about how strong the relationship is between remembering, communicating, and analyzing, we carried out a correlational analysis. A positive correlation between students' rational thinking abilities and misunderstanding will provide a realistic picture of a person's performance. We found no correlation between rational thinking skills and comprehension errors in the post-test (game group: $r = 10.39$, $p = 0.5$; text-based explanation group: $r = 7.88$, $p = 0.17$). Following, the difference in correlation coefficient is not significant ($Z = 1.95$, $p = 0.504$). Overall, these results support alternative hypothesis 2c.

4. DISCUSSION

We found differences between the group that used text-based explanations and the text-based explanation group regarding post-test scores on rational thinking skills with an effect convention of 0.38. These results align with alternative hypothesis 1c and show differences between previous researchers who only used video-based and game-based explanations (Kulgemeyer et al., 2022b). These results show significant differences based on the average post-test results through ANOVA data. In other words, Incorporating game-based explanations in education, particularly in schools, can enhance student engagement and learning outcomes. Research has shown that game-based learning is effective in various educational contexts. For example, Xu et al. (2023) discuss the use of game-based learning in medical education, highlighting its benefits in improving teaching processes.

Additionally, it provides insights into the impact of game-based learning and gamification in physical education through a systematic review and explores the balance between computational thinking and learning motivation in elementary programming education using game-based learning methods (Camacho-Sánchez et al., 2023). These studies support incorporating game-based explanations in educational settings to enhance student learning and motivation. Previous research implemented games but differed in media and time allocation (Anggraini et al., 2021; Li & Tsai, 2013).

Meanwhile, the results of students' misunderstandings show that they are consistent with alternative hypothesis 2b. This shows that there are misunderstandings carried out by students who have carried out the treatment in both the control class and the experimental class, resulting in results that are not much different or different between the control class and the experimental class; this is in line with research (Kulgemeyer & Wittwer, 2023). Two arguments support the misunderstanding conclusion:

1. The first argument comes from a theoretical point of view and is related to the study of material classification. From what we know about this, it can be said that both groups will likely require further instruction to understand complex material classifications fully. In science education, it is known that this particular concept is difficult to understand because of the many misunderstandings and because conceptual change is challenging to achieve in this context (Citra & Rosy, 2020; Annisette & Lafreniere, 2017). The time used in one meeting is likely to be less and less than optimal in developing learning, mainly due to the lack of a required reading list due to institutional policies that do not allow carrying smartphones. Additionally, as future science educators, we want our students to be critical enough of themselves to remain open to further teaching. If further learning is needed between the control and experimental classes, the class that requires further understanding is the class that experiences misunderstandings. For example, in text-based explanations, even though, in terms of material, it represents the entire material, we still need to understand whether the images are related to the classification of the material or not, so this does not rule out the possibility. Classes that use text-based explanations require further understanding of material classification (Davidson et al., 1988; Rosdiana et al., 2019).

2. The second argument comes from an empirical point of view. First, ANOVA of the knowledge-adjusted comprehension error scale at post-test showed significantly higher comprehension confidence in the text-based explanation group. Additionally, both groups scored

between 72% and 73% (no ceiling effect) on a test of rational thinking skills designed only for students with low content knowledge (Kulgemeyer et al., 2022a; Kulgemeyer & Wittwer, 2023). However, both groups were very positive about their understanding. This shows that there is a misunderstanding. In addition, the ANOVA analysis of the achievements of the two groups showed no relationship between test performance on the post-test and the ability to reason and understand in the two groups. This supports the assumption that no group does not have a realistic understanding, but both experience misunderstandings. In other words, using learning media with a socio-scientific approach to issues through game-based explanations can improve students' rational thinking abilities compared to using text-based explanations (Citra & Rosy, 2020; Solikah, 2020).

In summary, neither group performed well in actual learning, but the text-based explanation group performed poorly.

Based on these two arguments, we argue that both groups have misunderstandings, but the text-based explanation group has higher misunderstandings. The most likely reason is that the explanation media is text-based, and the time used is not long enough, so there are still misunderstandings, but this is not the only reason this happens (Astini, 2022; Subandowo, 2022).

5. CONCLUSION

Based on the data obtained on the ability to reason using both game-based explanations and text-based explanations, there is no significant difference because the effect of conventions obtained by the pretest from both groups is 0.19, which is smaller than 0.30, so it can be said that there is no significant difference. However, in the post-test, there was a significant difference between the control and experimental groups, with an effect size of 0.38, which is higher than 0.3, indicating a meaningful impact of the intervention on student outcomes. Significant. Meanwhile, in misunderstanding using ANOVA, the convention effect obtained was only 0.03, which means there was no significant difference. However, on average, the game class had a misunderstanding test score compared to the control class, which used text. This game-based explanation exceptionally influences misunderstanding with the SSI approach rather than text-based explanation classes.

STUDY IMPLICATIONS

First, our results support the increase in rational thinking ability learning outcomes that students, on average, obtain between game-based explanations, which are superior to text data-based explanations.

We see no reason why text-based textbook explanations should not be part of science teaching. Additionally, our results highlight potential dangers if institutions are left alone with game-based or written explanations. Both groups showed signs of misunderstanding. Previous research also shows that learning with explanations is generally only successful if the explanations are well embedded in ongoing cognitive activities such as learning tasks (Wittwer & Renkl, 2008). Working on learning tasks helps a person better assess his or her performance. Therefore, using learning tasks based on the content of instructional explanations can function as a countermeasure to the influence of text-based explanations on misunderstanding.

Further research is needed to increase learning insight through explanations using different media. However, we would like to reiterate that misunderstandings have potentially dangerous consequences for science learning (Kulgemeyer & Wittwer, 2022): if students believe that they have fully understood a topic, they may resist further teaching, taking into account it is redundant and irrelevant. In this way, they become less cognitively active (a core dimension of quality science learning). Additionally, they have to select further teaching material (e.g., in independent learning). In that case, they may stop once they are confident in their understanding, which may be true for both written and game-based explanations. This underlines that science teaching continues beyond providing explanations in certain media. The following learning task is needed to make students aware of what they do not yet understand. Further research is needed to explore the impact of misconceptions.

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