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Development Of Augmented Reality (AR)-Based Mindloops Magazine To Minimize Solar System Misconceptions Among Elementary School Students

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Abstract

Misunderstanding of the material or misconceptions in the learning process can hinder the success of learning at school. Therefore, this study aims to develop a learning tool in the form of AR-based Mindloops Magazine to reduce students' misconceptions about solar system materials. The type of research used is Research and Develop (RnD) with the ADDIE model which consists of the analyze, design, development, implementation, and evaluation stages. The subjects in the study were grade VI students of SDN 1 Tunjungmuli which consisted of an experimental class and a control class. The sampling technique used is random sampling. In the experimental class, learning was applied using AR-based Mindloops Magazine, while in the control class it used a student handbook. Data collection was carried out through interviews, questionnaires, and tests. Data were analyzed using qualitative and quantitative approaches. Quantitative analysis includes normality, homogeneity, and t-test. The results of the study show that AR-based Mindloops Magazine is in the category of valid and practical. Statistical tests showed that the data were normally distributed and homogeneous with values of 0.136 and 0.148 (both more than 0.05). In addition, the results of the t-test also obtained a significance value of 0.015 (less than 0.05). Thus, it can be concluded that the use of AR-based Mindloops Magazine learning media is effective in minimize students' misconceptions about solar system materials.

Keywords: Solar System, Magazine, Augmented Reality, Misconseption

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INTRODUCTION

Misconceptions are alternative understandings that differ from accepted scientific knowledge. Everyday experiences, the use of unscientific language, and errors in school learning can lead to misconceptions (Sertas et al., 2020). Misconceptions do not occur by chance, but rather result from students' attempts to integrate personal experiences with scientific concepts that actually contradict them. If misconceptions are not promptly identified, students' conceptual understanding will be hampered. Therefore, teachers need to identify student misconceptions through instructional adjustments (Muhabib et al., 2024).

Astronomy is a science field with a high number of misconceptions (Sertas et al., 2020). Misconceptions about the solar system also occur in several elementary schools. Preliminary research was conducted in the Diponegoro Cluster, Karangmoncol Sub-district Coordination, Purbalingga, consisting of eight schools. A total of 128 sixth-grade students were interviewed using a Google Form, asking questions related to misconceptions about the solar system. The analysis of diagnostic test items showed that 52% of respondents still had misconceptions about the seasons, which are caused by changes in the Earth's distance from the sun, and the fact that all planets orbit the sun in perfect orbits.

Students struggled with both topics due to the lack of media that could visualize the solar system. Consistent with this, interviews with several teachers also revealed a lack of interactive learning media. Available learning media are unable to explain abstract solar system material to students in a more concrete way, and interactive solar system media are minimally utilized. Textbooks can also lead to misconceptions, especially if they use difficult-to-understand language, lack precise explanations, and contain misleading images or graphs (Laksana et al., 2017). Therefore, learning media are needed that can serve as learning resources for students, providing a concrete and meaningful picture of the solar system.

One alternative media that can be used in learning and serve as a learning resource for students is digital magazines. A magazine is a collection of written and visual content systematically and engagingly designed to convey information, experiences, ideas, and personal reflections to readers (Gelmez et al., 2015). Magazines not only contain material but can also include reading material presented in the form of illustrated stories, scientific facts, and even quizzes that can provide more engaging material. Djuroto (in Kurniasari et al., 2022) argues that magazines are a simple medium for children, with relatively easy-to-understand content and a variety of stories added to enhance the nuances of the content and a varied presentation. The AR-based Mindloops Magazine can provide students with a learning experience similar to reading a

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magazine.

Concrete learning experiences are gained when students directly observe or experience natural phenomena. However, for solar system material, teachers cannot take students to see the solar system directly; they can instead use an alternative, AR. AR is a technology that integrates virtual objects with the real world, enabling users to see reality with embedded virtual elements, enabling students to access and understand complex concepts in a deeper and more intuitive way (Ginanjar et al., 2024).

AR-based learning can be easily accessed by students through devices supported by an application called Assemblr. The Assemblr application is an AR platform designed to simplify the process of designing 3D content that will later be displayed in AR form. This is done in an efficient and user-friendly manner (Ginanjar et al., 2024). Teachers and students can download this application free of charge through the Play Store or can also be directly with a barcode scanner application. The existence of AR-based Mindloops Magazine learning media is expected to be a link between scientific reality and students' imagination, thus transforming concepts that were initially abstract and difficult for students to understand into concrete and enjoyable visual experiences. Therefore, this study aims to develop an AR-based Mindloops Magazine product to minimize misconceptions about the solar system in elementary school students that meets the aspects of validity, practicality, and effectiveness.

Analysis Stage

Based on the results of a needs analysis conducted in a preliminary study involving sixth-grade teachers in the Diponegoro Cluster of the Karangmoncol Education and Culture Office (Dindikbud), it was concluded that the development of innovative learning media in the form of AR-based Mindloops Magazine was urgently needed. The analysis revealed that existing learning media did not maximize student motivation and interest in learning and did not strengthen student understanding of the material. Therefore, it can be concluded that in science and science learning on the solar system, engaging, innovative, and interactive learning media are needed to increase student motivation and interest in learning and enhance understanding of the material. These findings served as the basis for the researchers to develop an AR-based Mindloops Magazine product.

Design Stage

The design stage refers to the stages in designing the AR-based Mindloops Magazine

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learning media, which first determines the supporting media used in the production, then the content, and the initial product design. The supporting media used were Canva and Assemblr Edu. Next is the preparation of the magazine content in the form of collecting solar system material that will be an important part of the magazine content, dividing the material for each page, compiling the contents of each page starting from the front cover page, foreword, AR usage instructions, table of contents, main material, facts and myths of the solar system, quizzes, getting to know the author, back cover page. Lastly is the initial product design stage of the magazine which includes the magazine theme, selection of main characters in the magazine, magazine composition, and AR creation.

Development Stage

The development stage involved conducting validity testing by experts, namely material experts, media experts, and language experts. The assessment results from the three experts are presented in Table 2 below.

No	Aspect	Score	Category
	Material Expert		
1	Suitability with curriculum and learning objectives	82	Valid
2	Correctness and accuracy of scientific concepts	82	Valid
3	Depth and integration of the material	84	Valid
4	Contextual feasibility and student engagement	83	Valid
	Language Expert		
1	Readability and clarity of language	81	Valid
2	Suitability of language for students	82	Valid
3	Accuracy and consistency of language	83	Valid
4	Communicativeness and attractiveness of language	81	Valid
	Media Expert		
1	Feasibility of content and material	81	Valid
2	Feasibility of AR display and design	82	Valid
3	Feasibility of language and communication	81	Valid
4	Feasibility of learning and interactivity	81	Valid
5	Technical feasibility and usability	82	Valid

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Based on the table above, the data obtained from the validity tests conducted by the three experts showed that each component was categorized as valid. First, the assessment by the material expert indicated an average score of 82.8, which fell into the valid category. Second, the assessment by the language expert also showed that all categories were considered valid, with an average score of 81.8. Third, the assessment by the media expert demonstrated that all components achieved the valid category with an average score of 81.4. Therefore, it can be concluded that based on the evaluations of the three experts, the AR-based Mindloops Magazine on the solar system material that was developed has fulfilled the validity criteria.

Implementation Phase

After receiving feedback from the three validators, revisions or improvements were made to the AR-based Mindloops Magazine based on their suggestions and input. This phase also included a limited trial, or small group trial, and a field test. The limited trial involved 22 students from grade 8 of Tunjungmuli 1 Public Elementary School. This trial aimed to determine if students encountered any difficulties using the magazine. The results showed that students were able to use the AR-based magazine smoothly. The average practicality questionnaire score from the 22 students was 85, indicating that the AR-based Mindloops Magazine was considered practical for students to use in supporting learning related to the solar system. The field test involved implementing the AR-based Mindloops Magazine in both classes over three sessions.

Evaluate Phase

This final phase involved a comprehensive evaluation of the product's usability, based on statistical testing results. The post-test aimed to determine the effectiveness of using the AR-based Mindloops Magazine in minimizing student misconceptions about the solar system.

The t-test results showed a significance value of 0.015, which is less than 0.05, indicating a difference in the average scores between the experimental and control classes. The average conceptual understanding score for the class using the AR-based Mindloops Magazine was better than that of the class using only the student textbook. Furthermore, learning in the experimental class was more active and enjoyable. Therefore, learning using the AR-based Mindloops Magazine on the solar system is effective in minimizing misconceptions among elementary school students.

The practicality test results, based on user response questionnaires, showed 85% student and 88% teacher responses. This indicates that the AR-based Mindloops Magazine is easy to use

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for both students and teachers. Furthermore, it provides evidence that the AR-based Mindloops Magazine makes students more engaged in learning and understands the material more easily.

DISCUSSION

The research results indicate that the AR-based Mindloops Magazine developed meets the validity and practicality criteria, making it suitable for use in learning. This validity demonstrates that the magazine's content, physical appearance, and components are aligned with the learning objectives and characteristics of elementary school students. Furthermore, the practicality aspect indicates that the media is easy to use by both teachers and students and supports effective classroom learning. This finding aligns with previous research that suggests the use of AR can improve student understanding (Bakar et al., 2020).

The statistical analysis results for the normality test were 0.136 in the experimental class and 0.483 in the control class, and the homogeneity test was 0.148. Both data points were greater than 0.05, thus meeting the requirements for hypothesis testing using the t-test. The t-test result was 0.015, which is less than 0.05, indicating a significant difference between student learning outcomes in the experimental and control classes. The statistical test results can be used to prove that the AR-based Mindloops Magazine is effective in minimizing misconceptions about the solar system among elementary school students compared to using textbooks.

The research findings can significantly impact the implementation of learning in elementary schools, particularly in terms of utilizing technology as an innovative and engaging learning medium. The use of AR-based Mindloops Magazine has proven effective not only in enhancing learning but also in helping students better understand abstract concepts and minimize misconceptions about the solar system. Therefore, the AR-based Mindloops Magazine learning medium can be used by teachers as an alternative to more interactive and contextual learning strategies. Furthermore, the research results also demonstrate the importance of AR integration in supporting meaningful and student-oriented learning. Therefore, the development of technology-based learning media is also necessary to support the improvement of learning quality in elementary schools.

The research findings demonstrate that the AR-based Mindloops Magazine possesses strong validity and practicality as an instructional medium for elementary school learning. The validity of the media indicates that the learning content, design structure, visual presentation, and interactive AR components are systematically aligned with curriculum objectives and the cognitive development characteristics of elementary school students. According to constructivist learning

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theory proposed by Jean Piaget, elementary school students are generally in the concrete operational stage, where they learn more effectively through direct visualization, interaction, and concrete representations of abstract concepts. In this context, the integration of Augmented Reality (AR) into the Mindloops Magazine provides students with visual and interactive experiences that transform abstract astronomical concepts into observable learning objects. The solar system, which is often difficult for students to imagine through textbooks alone, becomes more accessible through three-dimensional visualization and interactive exploration. Consequently, students can actively construct knowledge through observation and engagement rather than passive memorization. This finding supports the argument that technology-based learning media can bridge the gap between abstract scientific concepts and students' cognitive readiness in elementary education (Piaget, 1972; Bakar et al., 2020).

In addition, the practicality results reveal that the AR-based Mindloops Magazine is easy to implement in classroom learning and can be effectively utilized by both teachers and students. This practicality is closely related to the principles of meaningful learning theory developed by David Ausubel, which emphasizes that learning becomes more meaningful when new information is connected with students' prior knowledge through engaging instructional experiences. The AR features embedded in the magazine encourage students to interact directly with learning materials, thereby increasing motivation, attention, and curiosity during the learning process. Interactive media also reduce teacher-centered instruction because students become more involved in independent exploration and collaborative discussion activities. The practicality of the media demonstrates that educational technology can support a more student-oriented learning environment where teachers function as facilitators rather than the sole source of information. Furthermore, the combination of visual elements, animation, and digital interaction contributes to greater learning engagement, which is an essential factor in elementary education because students at this age are highly responsive to attractive and interactive learning stimuli (Ausubel, 1968; Mayer, 2014).

The statistical analysis further strengthens the effectiveness of the AR-based Mindloops Magazine in improving student learning outcomes and minimizing misconceptions about the solar system. The normality test results of 0.136 in the experimental class and 0.483 in the control class, as well as the homogeneity test result of 0.148, indicate that the data met the assumptions required for hypothesis testing using the t-test because all significance values exceeded 0.05. The t-test result of 0.015, which is lower than 0.05, confirms a statistically significant difference between the experimental and control classes. This finding proves that students who learned

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using the AR-based Mindloops Magazine achieved better conceptual understanding than students who learned through conventional textbooks. From the perspective of cognitive theory of multimedia learning proposed by Richard E. Mayer, multimedia-based instruction enhances learning because students process information through both visual and verbal channels simultaneously. The AR technology in the Mindloops Magazine allows students to combine textual explanations with dynamic visual representations, thereby reducing cognitive overload and helping learners organize information more effectively. As a result, misconceptions related to the solar system can be minimized because students gain clearer conceptual visualization compared to static textbook illustrations. This demonstrates that AR-based learning media can improve both conceptual understanding and long-term knowledge retention among elementary school students (Mayer, 2014; Moreno & Mayer, 2007).

Moreover, the effectiveness of the AR-based Mindloops Magazine can also be analyzed through the lens of social constructivist theory introduced by Lev Vygotsky. Vygotsky emphasized that learning occurs through social interaction and collaborative experiences within the Zone of Proximal Development (ZPD). The implementation of AR technology in classroom learning encourages collaborative exploration among students as they discuss observations, solve conceptual problems, and interpret digital visualizations together. Such interaction enables students to construct understanding collectively while receiving guidance from teachers and peers. In this sense, AR technology does not merely function as a visual tool but also as a medium that promotes communication, discussion, and cooperative learning. The interactive nature of the Mindloops Magazine supports active participation and inquiry-based learning, which are essential characteristics of twenty-first-century education. Consequently, the media contributes not only to cognitive development but also to the enhancement of social and communication skills among learners (Vygotsky, 1978; Ibáñez & Delgado-Kloos, 2018).

Furthermore, the research findings indicate broader implications for the implementation of technology-integrated learning in elementary schools. The successful use of the AR-based Mindloops Magazine reflects the growing importance of digital innovation in responding to contemporary educational challenges. In the digital era, traditional textbook-centered learning is often insufficient to meet the learning preferences and technological familiarity of modern students. Therefore, integrating AR into instructional media represents an innovative strategy to create contextual, engaging, and meaningful learning experiences. This finding aligns with the principles of twenty-first-century learning, which emphasize creativity, critical thinking, communication, and digital literacy. Through AR-based learning, students are not only acquiring

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scientific knowledge but are also developing technological competence and problem-solving skills. Teachers, meanwhile, are encouraged to adopt more innovative pedagogical approaches that integrate digital tools into classroom instruction. Consequently, the development of AR-based educational media can contribute significantly to improving the quality of elementary education and preparing students for future technological advancements (Bakar et al., 2020; Kurniawan et al., 2021).

Overall, the research confirms that the AR-based Mindloops Magazine is a valid, practical, and effective learning medium for minimizing misconceptions about the solar system among elementary school students. The integration of AR technology enhances conceptual understanding by providing interactive and visual learning experiences that align with students' cognitive characteristics and learning needs. Supported by constructivist, multimedia, and social learning theories, the findings demonstrate that AR-based learning media can transform conventional instruction into a more engaging, student-centered, and meaningful educational process. Therefore, the implementation of AR technology in elementary education should continue to be developed as part of broader efforts to improve learning quality, encourage innovation, and foster students' active participation in the learning process (Piaget, 1972; Mayer, 2014; Vygotsky, 1978).

CONCLUSION

This study concludes that the implementation of daily religious habituation programs at Junior Highschool Umbulsari Jember contributed significantly to the development of students' spiritual intelligence. Religious activities such as congregational prayer, Qur'anic recitation, daily supplication, charity programs, and moral reflection sessions successfully created a spiritually supportive school environment that encouraged students to internalize Islamic values in their daily lives. The findings revealed that continuous religious habituation positively influenced students' self-awareness, emotional control, discipline, empathy, moral behavior, and social responsibility. Students became more respectful toward teachers and peers, more disciplined in school activities, and more sensitive to social and ethical issues. Spiritual activities also helped students develop emotional calmness and positive interpersonal relationships within the school environment.

The study further indicates that teacher commitment, supportive school culture, and consistent implementation of spiritual programs became important factors supporting the effectiveness of religious habituation. However, several challenges such as digital distractions,

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differences in family background, and varying levels of students' spiritual maturity still influenced participation and spiritual engagement. Overall, daily religious habituation proved to be an effective strategy for strengthening students' spiritual intelligence and character formation. The integration of practical spiritual experiences into school culture contributed positively to holistic student development by balancing intellectual growth with moral and spiritual maturity.

FUTURE DIRECTIONS

Future research is recommended to expand the implementation of the AR-based Mindloops Magazine across broader educational contexts and subjects in order to evaluate its long-term effectiveness and adaptability in elementary education. Future studies may investigate the integration of AR technology with other interactive learning approaches such as gamification, collaborative learning, or problem-based learning to further enhance students' critical thinking, creativity, and digital literacy skills. In addition, researchers are encouraged to involve larger and more diverse participant groups from different regions and educational backgrounds to strengthen the generalizability of findings. Further investigation is also needed to examine the long-term impact of AR-based learning media on students' retention, motivation, and conceptual understanding, particularly in science learning. Moreover, future developments should focus on improving the accessibility, usability, and technological compatibility of AR media so that teachers can implement it more effectively in various classroom conditions and educational environments.

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