SYSTEMATIC LITERATURE REVIEW: DEVELOPMENT OF AUGMENTED REALITY-BASED E-LKPD TO IMPROVE STUDENTS' CREATIVE THINKING SKILLS AND LEARNING INTEREST IN MATHEMATICS

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Abstrak

Penelitian ini merupakan studi Systematic Literature Review (SLR) yang bertujuan untuk mengidentifikasi dan menganalisis pengembangan e-LKPD berbasis Augmented Reality (AR) dalam meningkatkan kemampuan berpikir kreatif dan minat belajar siswa dalam mata pelajaran matematika. Pendekatan SLR digunakan untuk menyusun sintesis dari 15 artikel ilmiah yang relevan dan telah dipublikasikan pada rentang waktu 2018 hingga 2025. Artikel-artikel tersebut diperoleh melalui pencarian sistematis di basis data Google Scholar dan Semantic Scholar dengan menggunakan kata kunci yang disesuaikan. Hasil analisis menunjukkan bahwa penggunaan e-LKPD berbasis AR memberikan pengaruh positif yang signifikan terhadap peningkatan dua aspek penting dalam pembelajaran matematika, yaitu kemampuan berpikir kreatif dan minat belajar siswa. Teknologi AR terbukti mampu menyajikan materi pembelajaran **secara** lebih visual, interaktif, dan kontekstual, yang pada akhirnya mendorong keterlibatan aktif siswa dalam proses pembelajaran. Melalui visualisasi tiga dimensi dan pengalaman belajar yang mendekati dunia nyata, siswa menjadi lebih tertarik, terlibat, dan terdorong untuk mengeksplorasi materi matematika secara mandiri. Temuan ini mengindikasikan bahwa media pembelajaran interaktif berbasis teknologi seperti AR dapat menjadi salah satu solusi inovatif untuk menjawab tantangan pembelajaran di abad ke-21. Studi ini memberikan landasan teoritis yang kuat bagi para pendidik dan pengembang media dalam merancang pembelajaran matematika yang lebih menyenangkan, bermakna, dan mendorong daya cipta siswa.

Kata kunci: SLR, Augmented Reality, Student Worksheet

Abstract

This research is a Systematic Literature Review (SLR) study that aims to identify and analyze the development of Augmented Reality (AR)-based electronic Student Worksheets (e-LKPD) in enhancing students' creative thinking skills and interest in learning mathematics. The SLR method was employed to compile a synthesis of 15 peer-reviewed scientific articles published between 2018 and 2025. The articles were obtained through systematic searches using tailored keywords on academic databases such as Google Scholar and Semantic Scholar**.** The findings from the review indicate that AR-based e-LKPD has a significant positive impact on improving both students' creative thinking and their motivation to learn mathematics. AR technology has been shown to effectively deliver learning content in a more visual, interactive, and contextual format**,** which enhances students' active participation in the learning process. Through 3D visualization and immersive, real-world-like learning experiences, students become more interested and engaged, and are motivated to explore mathematical concepts independently. These findings suggest that AR-based interactive learning media can serve as an innovative solution to meet the demands of 21st-century education**,** particularly in STEM-related fields. This study provides a strong theoretical foundation for educators, instructional designers, and media developers in integrating AR into mathematics education. It underscores the importance of combining pedagogy and technology to create engaging, meaningful, and student-centered learning experiences that foster creativity and deeper understanding.

Keywords: SLR, Augmented Reality, Student Worksheet

INTRODUCTION

The learning process is very important in life (Blossfeld & Von Maurice, 2019). This is because the existence of learning new knowledge and new experiences conveys it (Hohr,

2013). This knowledge is used as capital for students to acquire new knowledge and solve problems (Pamungkas & Khaerunnisa, 2020). Effective learning should include elements of interactivity, both between students and teachers and between students themselves, so that the learning atmosphere becomes more interesting, challenging, and encourages the development of creativity and independence of students (Ambarini et al., 2018).

At this time, the learning process at school is not in accordance with expectations, including mathematics learning (Young-Loveridge, 2004). The learning carried out tends to be teacher-centered. Teachers teach with a lecture or presentation approach, while students only take notes in their books. In a mathematics learning situation like this, students tend to only memorize and remember formulas (Kloosterman, 2002). As a result, mathematics feels more difficult and boring, which makes the creative thinking skills of students learning mathematics less honed. In line with Sitorus (2016), creative thinking skills are rarely seen in mathematics learning because the applied model tends to be oriented towards the analytical development of routine problems. In fact, the goal of creative thinking is that students are able to find new ways to solve mathematical problems in a variety of ways (Svecova et al., 2014). Therefore, the lack of innovation in mathematics learning reduces students' understanding of concepts, learning interests, and creative thinking skills.

The results of previous studies show that students' mathematical creative thinking skills and learning interests still need to be improved (Kusuma et al., 2020; Dwijanto et al., 2019; Rohaeti et al., 2019). Based on the results of an international survey conducted by the *Organization for Economic Co-Operation and Development (OECD)* in the *Programme for International StudentsAssessment (PISA)* in 2017, Indonesia scored 379 in terms of mathematical literacy (Numeracy) and occupied the bottom 10 positions out of 79 participating countries (Nurqamar & Nur, 2022). This shows that there is a problem in the effectiveness of mathematics learning in Indonesia. This condition is a serious challenge in developing the quality of mathematics learning that is relevant to the needs of the 21st century.

Although there has been a lot of research on learning media based on *augmented reality technology*, most of it is still focused on improving students' creative thinking skills or learning interests separately. Studies that specifically integrate these two aspects in the context of digital media development, especially Augmented Reality (AR)-based e-LKPD, are still limited and have not been widely mapped systematically. In fact, the use of Augmented Reality technology in learning has significant potential in increasing student participation through the presentation of materials that are more visually appealing, interactive, and contextual. However, there is still a limited number of studies that specifically examine the effectiveness of developing Augmented Reality-based e-LKPD to improve students' creative thinking skills and interest in learning mathematics simultaneously.

In this digital age, students are familiar with technology and expect a more interactive and relevant learning experience. The use of Augmented Reality is indispensable in mathematics learning to create a more interesting, visual, and contextual learning experience, thereby increasing students' interest and motivation to learn (Estapa & Nadolny, 2015; Chen, 2019). Thus, the development of Augmented Reality-based e-LKPD is an important thing in an effort to improve students' creative thinking skills and learning interest in mathematics. This study is expected to provide concrete evidence of the effectiveness of Augmented Reality-based e-LKPD in improving the quality of mathematics learning in accordance with the demands of 21st century learning.

METHOD

This study uses the Systematic Literature Review (SLR) method, which is a method that focuses on the process of identifying, evaluating, and synthesizing various literature

relevant to the research topic in a systematic, structured, and planned manner. The purpose of this method is to compile a comprehensive and objective summary of existing research findings, so that it can be used as a strong theoretical basis for the development of further studies. In the data collection process, the researcher used 12 articles obtained from Google Scholar and Sematic Scholar with a range of 2018 to 2025. The article consists of 6 articles that discuss the development of Augmented Reality-based e-LKPD to improve students' creative thinking skills, 3 articles on the development of Augmented Reality-based e-LKPD to increase students' interest in learning, and 3 articles that examine the development of Augmented Reality-based e-LKPD to improve both aspects at once, namely creative thinking skills and students' learning interest in learning mathematics. All selected articles are presented in the form of a table that includes information about the title, author, year of publication, and research findings. The results of this study provide a solid basis to support the development of interactive learning media in the form of Augmented Reality-based e-LKPD which aims to improve students' creative thinking skills and learning interest in mathematics.

RESULTS AND DISCUSSION

The results of the literature review conducted from 15 articles are divided into 3 parts, namely 6 articles on the development of augmented reality-based e-lkpd to improve creative thinking skills, 3 articles on the development of augmented reality-based e-lkpd to increase students' interest in learning, 6 articles on the development of augmented reality-based e-lkpd to improve creative thinking skills and students' interest in learning mathematics. The results are presented in the following section:

1. Research on the development of augmented reality-based e-lkpd to improve creative thinking skills

   The following are some research articles on the development of augmented reality-based e-lkpd to improve creative thinking skills presented in Table 1.

Table 1. Research on creative thinking skills

Journal	Author	Research Results
Jurnal Program Studi Pendidikan Matematika Volume 13, No. 3, 2024, 826-837	Puspita, G.	Further implementation findings show that e-modules based on design thinking projects, assisted by augmented reality, are beneficial in improving the developed mathematical creative thinking skills.
Jurnal Tadris IPA Indonesia Volume. 3 No. 3, 2023, pp. 303 - 314	Oktaviyanti, R., dkk.	The results showed that STEM-based teaching materials using Augmented Reality were declared valid to be used to improve students' critical thinking skills, with an average of 84.4%.
DE_JOURNAL (Dharmas Education Journal) E-ISSN : 2722-7839, P-ISSN : 2746-7732 Volume. 4 No. 1 Juni (2023), 331-337	Filahanasari, E.	This study aims to describe the feasibility of contextual-based LKPD that is oriented to students' creative thinking skills in linear program materials in high school. The results of the study show that the contextual-based LKPD developed has proven to be feasible, practical, and effective enough to support learning and develop students' creative thinking skills.
International Journal of Research Publication and	T. Molina, I.M., & Chua, E.N.	The results indicated that the use of the Augmented Reality Teaching Tool led to an improvement in students' performance

Reviews, Volume 5, no 6, pp 5105-5112 June 2024		task scores related to their creative thinking skills, including creativeness, analytical thinking, and problem-solving.
Journal of Physics: Conference Series 2377 (2022) 012084 IOP Publishing doi:10.1088/1742-6596/2377/1/012084	Muhammad, M.	Based on the results of this synthesis, we need to develop Learning Media Augmented Reality that integrates STEM approaches to improve students' creative thinking skills
Scientechno: Journal of Science and Technology, 3(1) - April2024105-117	Hurulean, F. A., & Miliyawati, B.	The results showed that students who received learning through Realistic mathematics context assisted by Augmented Reality Technology (ART) were significantly superior to the improvement of mathematical creative thinking skills comparedto students who received Ordinary Learning (OL)

Based on Table 1, various studies show that the use of *Augmented Reality* (AR)-based learning media has a positive impact on improving students' creative and critical thinking skills, especially in mathematics learning. One of the important findings is that the use of project-based e-modules with *a design thinking* approach combined with AR technology has been proven to be able to develop students' mathematical creative thinking skills. This e-module facilitates students in exploring ideas, solving problems, and developing solutions creatively.

In addition, teaching materials based on STEM approaches that utilize AR are declared valid and feasible to be used in learning. The results of the study show that this teaching material is able to improve students' critical thinking skills with a feasibility percentage of 84.4%. Contextual-based LKPD developed for linear program materials has also been proven effective in supporting learning and improving the creative thinking skills of high school students.

Other research shows that AR learning aids are able to improve student performance in tasks that require creative, analytical, and problem-solving thinking. The use of realistic mathematical contexts supported by AR technology has also been shown to result in a significant improvement in students' mathematical creative thinking abilities compared to regular learning. These findings underscore the need to develop AR-based learning media that integrates STEM approaches and real-world contexts to optimize students' creative thinking potential in today's digital era.

2. Research on the development of augmented reality-based e-lkpd to increase students' interest in learning

The following are some research articles on the development of augmented reality-based e-lkpd to increase students' interest in learning mathematics presented in Table 2.

Table 2. Research on students' learning interests in mathematics

Jurnal	Penulis	Hasil Penelitian
Jurnal Visi Ilmu Pendidikan Volume 14, No 2 (2022)	Selfia, K. D., & Dias Aziz Pramudita, S. P.	This research has the goal of developing AR-based learning media to increase students' interest and learning outcomes in the learning process. The subject of the media test was carried out on class X students using

		the SUS method and was carried out by media experts and material experts by collecting data using questionnaires. So that it is stated that the Basic Graphic Design learning media based on Augmented Reality is feasible to be implemented for students.
JNPM (Jurnal Nasional Pendidikan Matematika) Volume 7, No. 1, Maret 2023	Sari, I. N., & Sulisworo, D.	This study aims to develop Augmented Reality (AR)-based student worksheets (LKPD) on the building material of flat side space on the subject of cubes. Based on the results, it can be seen that the development of AR-based LKPD can attract the interest and motivation of students to learn mathematics. This learning media can be used to make it easier for students to reason about the third dimension, especially building a cube space.
JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika) Volume. 10, No. 1,Maret 2025, Pp. 519-532	Moch Shobachus Surur & Rohman Djaya	This research develops Augmented Reality-based mathematics learning media on spatial building materials. The goal of this development is to increase students' interest in learning through interactive and engaging applications. The app is designed using Blender and Unity software, with the EasyAR SDK, and includes eight types of build spaces. The results of the study show that this application is effective in increasing students' interest in learning materials for building spaces.

Based on Table 2, this study generally aims to develop *Augmented Reality* (AR)-based learning media to increase students' interest and learning outcomes, especially in mathematics and graphic design learning. Some of the studies in this study highlight the development of interactive media that utilizes AR technology to deliver material in a way that is more visual, engaging, and easy for students to understand. One part of the research developed an AR-based "Basic Graphic Design" learning media which was tested on grade X students using *the System Usability Scale* (SUS) method. In addition, validation was carried out by media experts and material experts through a questionnaire, the results of which stated that the media was feasible to be implemented in the learning environment.

In the context of mathematics learning, this study developed *an AR-based Student Worksheet* (LKPD) that focuses on building materials for flat-sided spaces, especially cubes. This LKPD is designed to help students understand the concept of the third dimension in a more concrete, visual, and interactive way. The results show that this media is able to increase students' interest and motivation in learning mathematics. In addition, the development of AR applications with the help of Blender and Unity software, as well as the EasyAR SDK, successfully covers eight types of building spaces. This application has proven to be effective in increasing students' interest in the material, making learning more enjoyable and away from monotonous impressions. This research shows that the integration of AR in learning has great potential in improving the quality of the teaching and learning process.

3. Research on the development of augmented reality-based e-lkpd to improve creative thinking skills

   The following are some research articles on the development of augmented reality-based e-lkpd to improve students' creative thinking skills and learning interest in mathematics presented in Table 3.

Table 3. Research on students' creative thinking skills and learning interest in mathematics

Journal	Author	Research Results
Musamus Jurnal of Mathematics Education, 1(1), 1-16.	Palobo, M., & Meirista, E	This research aims to improve students' creative thinking skills and interest in learning mathematics. The results of the study were obtained that the learning tool with the Problem Solving approach met the valid criteria based on the assessment by three validators. Meanwhile, assessment instruments in the form of creative thinking ability test questions and learning interest questionnaires also meet valid criteria.
JNPM (Jurnal Nasional Pendidikan Matematika) Volume 7, No. 1, Maret 2023	Noverianto, B., & Munahefi, D. N.	This study developed an AR-based LKPD on flat side space building materials, especially cubes, with a Problem Based Learning model. The results of the study show that the use of LKPD can attract students' interest and motivation in learning mathematics.
JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika Volume. 10, No. 1, Maret 2025, Pp. 519-532	Surur, M. S., dkk.	This research aims to develop learning media in android-based mathematics subjects with Augmented Reality in building space materials and fostering learning interests for students. The results of this study stated that this application is very useful for students' learning interests because it can make the material seem more interesting, interactive, and can be played to avoid student boredom in mathematics learning subjects, especially building space materials.
PYTHAGORAS: Jurnal Pendidikan Matematika, Volume 13 (1), 2018, 63-75	Hidayat, P. W., & Widjajanti, D. B.	This study compares the effectiveness of the CTL approach with *open ended* and regular CTL questions on the creative thinking ability and learning interest of junior high school students. The results showed that the CTL approach with *open ended questions* was better in improving creative thinking skills (high category), while ordinary CTL was only in the medium category. Students' interest in learning in both classes was in the high category and increased significantly, but there was no significant difference between the two approaches in terms of learning interest. The most prominent aspect of creative thinking in both classes is fluency.
Proceeding	Akbar, N. N., &	Based on the results of the study, the

Seminar Nasional IPA. July 2023	Savitri, E. N.	application of the Think Pair Share (TPS) learning model has been proven to be able to increase students' creative thinking skills and learning interests in science subjects, especially in *Earth and Solar System materials*. Previously, students' learning interests were in the medium category and creative thinking skills under the KKTP. After the implementation of TPS in two cycles, there was an increase in interest in learning by 43% and student creativity increased by 55% overall. This shows that the TPS model is effective in creating more interesting and interactive learning for students.
Prosiding Sendika: Volume 5, No 1, 2019	Pangestu et al.	This study aims to determine the use of augmented reality-based spatial geometry teaching media that is oriented to students' interest in learning mathematics. The method used in this study is a literature study, which is to review relevant previous studies and conclude based on the results obtained. The result of this study is that augmented reality-based learning media oriented to students' interest in learning mathematics can be used in learning spatial geometry

Based on Table 3, this study aims to improve students' creative thinking skills and interest in learning mathematics by developing innovative learning tools based on *the Problem Solving* approach and *the Problem Based Learning (PBL)* model. The main focus of development is directed at building materials for flat-sided spaces, especially cubes, which have been considered difficult and unattractive by most students. To answer these challenges, the researcher developed a Student Worksheet (LKPD) based on *Augmented Reality (AR)* technology and learning media based on Android applications.

The results of the study show that the developed learning tools have been assessed to meet valid criteria by three expert validators, both in terms of content, construction, and language. Assessment instruments that include creative thinking ability test questions and learning interest questionnaires have also proven to be valid and feasible to be used to measure the achievement of learning goals. Furthermore, the use of AR-based LKPD is able to attract students' attention and increase their enthusiasm in following the mathematics learning process. Students become more active, engaged, and motivated because the material is presented visually, interactively, and fun.

This AR-based learning application not only enriches students' learning experience, but also helps them understand mathematical concepts in a concrete way, especially in recognizing the shape, size, and structure of building spaces. The interactive features on the application make students feel as if they are "playing while learning", thus reducing the boredom that often occurs in conventional learning. Thus, the use of technology in mathematics learning has been proven to be effective in increasing interest in learning as well as developing students' creative thinking skills. This research is proof that innovation in learning, especially through the use of

technology, has great potential to bring positive changes in the teaching and learning process.

CONCLUSION

Based on the systematic analysis of the reviewed literature, it can be concluded that there is a strong and consistent foundation to support the development of Augmented Reality (AR)-based electronic Student Worksheets (e-LKPD) as a means to enhance students' creative thinking skills and learning interest in mathematics. The findings from the 15 selected studies clearly demonstrate several important points that reinforce the potential of AR-based learning media. First, AR-based e-LKPD has been proven to be feasible and practical to develop in various educational contexts, both in terms of technological integration and pedagogical relevance. The combination of interactive visuals and contextual representations allows for a more engaging learning experience.

Second, the implementation of AR technology in mathematics learning has shown significant improvements in students' creative thinking abilities. Through exploration, problem-solving, and interaction with augmented objects, students are encouraged to think outside the box, develop original ideas, and apply mathematical concepts creatively in novel situations. Third, AR has a powerful effect on increasing students' interest and motivation to learn mathematics, a subject often perceived as abstract and challenging. The novelty and interactivity of AR applications help reduce learning anxiety and promote positive attitudes toward mathematics.

Therefore, these findings provide a solid theoretical and empirical basis for future research and practical efforts in designing and implementing AR-based e-LKPD. Such development not only aligns with the goals of 21st-century learning but also serves as an innovative solution to transform mathematics classrooms into dynamic, student-centered environments that foster curiosity, creativity, and deeper understanding.

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