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Development of Augmented Reality (AR) Learning Media with the Project-Based Learning Model to Improve Motivation and Learning Outcomes in Projection Drawing

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ABSTRACT

The low level of students' spatial understanding and the limited availability of dynamic visual media capable of facilitating three-dimensional object representation in projection drawing learning constitute a strategic educational problem. Students often experience difficulties in visualizing spatial relationships, which affects both their motivation and learning outcomes. To address this issue, this study developed augmented reality (AR) learning media using the 4D development model, consisting of Define, Design, Develop, and Disseminate stages. The purpose of this research was to improve students' learning motivation and learning outcomes in projection drawing instruction. This research was conducted in the Visual Arts Education Study Program at Universitas Pendidikan Ganesha, involving 22 students as research subjects. Data were collected through interviews, observations, questionnaires, tests, and documentation. The research instruments included expert validation sheets, motivation questionnaires, and learning outcome tests. All instruments were validated by content experts, media experts, and instructional design experts. Data analysis techniques comprised descriptive analysis, normality testing, Wilcoxon tests, paired-sample t-tests, and N-gain analysis to determine the effectiveness of the developed media. The results showed that the AR learning media was highly feasible, with a validation score of 91% from content experts and 88% from media experts. Individual, small-group, and field trials indicated positive student responses, with acceptance rates between 81% and 91%. The mean pretest score increased from 41.00 to 72.41 in the posttest, with an N-gain value of 0.52 (moderate category). Students' learning motivation also increased significantly ($p = 0.000$). Therefore, the developed AR media is feasible and effective for projection drawing learning.

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1. INTRODUCTION

Education is a highly important process in the development of Human Resources (HR). The success of education is not only determined by the system, but also highly dependent on the role of teachers as designers and implementers of learning. The effectiveness of learning is determined by the appropriateness of models, methods, and strategies adjusted to the characteristics of learners [1]. This means that the quality of learning depends on the teacher's ability to accurately identify learners' learning needs.

Based on this understanding, identifying learning needs becomes a crucial step in designing effective instruction. Each learner has diverse learning needs, encompassing cognitive, affective, and psychomotor aspects [2]. In the cognitive aspect, students require clear understanding, well-organized material structures, and the development of critical thinking skills [1]. International journals indicate that approaches such as Project-Based Learning and Problem-Based Learning are effective in improving higher-order thinking skills. This is reinforced by Pratiwi's research [3], which found that the project-based e-learning model significantly improved vocational high school students' critical thinking skills, demonstrating that project-based approaches are not only effective for knowledge transfer but also for the development of higher-level cognitive skills.

In addition to cognitive aspects, the affective dimension also plays a central role in learning. Emotional factors such as motivation, self-confidence, and teacher support influence learning success. Intrinsic motivation encourages interest from within [4], while extrinsic motivation arises from environmental stimuli [1]. Learners with high self-efficacy tend to be more resilient in facing obstacles and more capable of achieving learning goals [5]. Rampisela, in his research, confirmed that appropriate learning strategies can simultaneously develop students' achievement motivation and self-efficacy, where high self-efficacy positively correlates with academic achievement [6]. A conducive school environment is also an important factor in fostering learning comfort [7].

The psychomotor and social dimensions complement holistic learning needs. Social needs such as interaction and collaboration are essential elements in learning. Vygotsky's theory through the concept of the Zone of Proximal Development (ZPD) emphasizes that an individual's ability can develop more optimally through assistance from more competent peers [8]. Constructive feedback from teachers and peers has also been proven to enhance understanding [9].

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Entering the digital era, the complexity of learning needs has undergone significant transformation. Learners require access to digital resources and technology-based learning methods, such as blended learning and e-learning [10]. Various studies emphasize the importance of utilizing interactive media, digital evaluation, and the application of learning theories such as Bloom's Taxonomy, constructivism, and Kolb's learning cycle [11]. The use of active methods such as Flipped Classroom, gamification, Virtual Reality (VR), and Augmented Reality (AR) has been shown to increase learners' motivation and understanding [12]. Warpala and Santyasa demonstrated that the flipped classroom model significantly improves students' critical thinking skills and positive attitudes in physics learning, indicating that technological innovation in learning can fundamentally transform classroom dynamics.

This transformation aligns with the characteristics of digital native learners, who bring new challenges. They are accustomed to rapid access to information, the use of gadgets, digital communication, and a preference for visual and interactive media [13]. This generation is more interested in flexible, personalized, and technology-based learning [13]. Therefore, modern learning media must fulfill aspects of interactivity, visualization, accessibility, personalization, and gamification elements. Suartama [14], in his research on gamification for case and project-based online learning, found that the implementation of gamification elements in project-based learning significantly increased student engagement and learning achievement in higher education.

To address these needs, educational technology plays a strategic role. According to AECT (1994) in Muldiyana [15], instructional technology includes the processes of designing, developing, utilizing, and evaluating learning resources. Digital technology that operates automatically and practically offers great potential to improve learning quality [16]. Digital learning media have been proven to facilitate material delivery and increase students' interest through visualization and interaction [17].

In the context of art education, the need for advanced learning media becomes highly relevant. Art education in higher education does not only focus on expressive ability but also emphasizes mastery of technical competencies, one of which is projection drawing skills. The Projection Drawing course in the Art Education Study Program at Universitas Pendidikan Ganesha (Undiksha) is a foundational course aimed at developing systematic visual representation, spatial ability, and form construction skills. Mastery of projection concepts—whether orthogonal, isometric, perspective, or other views—serves as an essential foundation for the development of advanced skills such as graphic design, technical illustration, product design, architecture, and animation.

However, the observed learning conditions among first-year students indicate an imbalance between the complexity of the required competencies and the instructional approaches used. Initial observations suggest that learning is still dominated by expository patterns: lecturers explain material through lectures or simple demonstrations without the support of interactive media that enable active student involvement. Students tend to

become passive recipients of information. Meanwhile, according to Marhamah [1], learning success is largely determined by the suitability of models, methods, and strategies applied to learner characteristics and material needs. Widiana [18], in a needs analysis of student-centered learning model development, emphasized that student-centered learning is an urgent necessity to improve students' reasoning and character, especially in subjects requiring deep conceptual understanding.

The mismatch in instructional approaches is confirmed by empirical data. The inconsistency in instructional approaches is reflected in the preliminary questionnaire data given to students, presented in Figure 1 below.

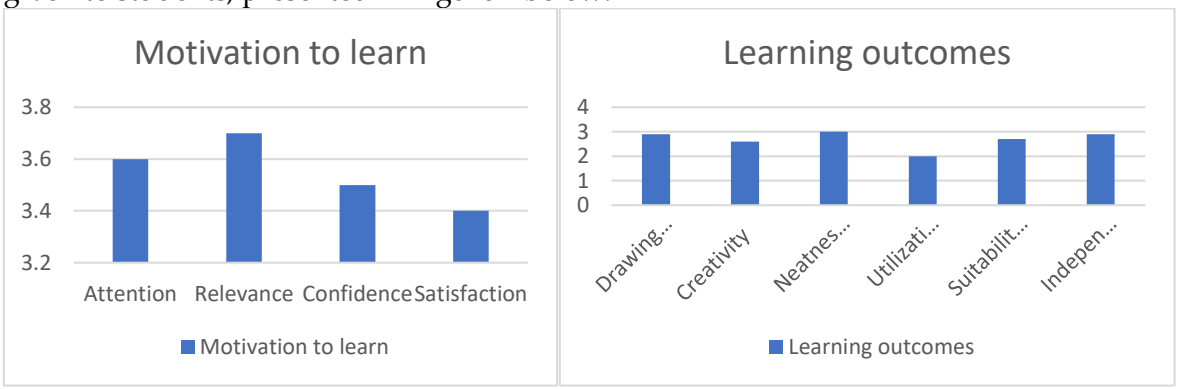

Figure 1. Needs Analysis Chart

Based on the results of the motivation questionnaire administered before the implementation of Augmented Reality-based learning media, students' motivation levels in the Projection Drawing course were categorized as low to moderate. The Attention dimension obtained an average score of 2.8, indicating that students were less interested and focused in conventional learning. The Relevance dimension, with a score of 2.9, indicates that students had not fully understood the connection between the material and their academic needs or future careers. In the Confidence dimension, the average score of 2.7 shows low self-confidence in completing Projection Drawing-based tasks, while the Satisfaction dimension, with a score of 2.6, indicates that the learning experience had not provided optimal satisfaction. Overall, the average motivation score of 2.75 falls within the Low–Moderate category, making it an important baseline for the need to develop more interactive media. This low motivation needs to be understood within the framework of learning motivation theory. Lasha [4] explains that intrinsic motivation arises from internal drives when learners feel interested and satisfied with learning activities. Conversely, Liang Gie [1] emphasizes that extrinsic motivation is influenced by external stimuli such as the learning environment and instructional media. Tegeh and Warpala [19] also proved that project-based learning models can increase motivation by up to 34% compared to conventional learning.

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In addition to motivation, students' understanding of basic projection concepts is also a major obstacle. Projection Drawing material requires three-dimensional spatial ability, while the learning process is still dominated by two-dimensional visualization through whiteboards and static illustrations. This condition causes students difficulty in conceptually understanding the transformation of 3D objects into 2D representations. Marhamah [1] states that an individual's cognitive aspect is influenced by interaction with the learning environment and experiences gained; therefore, the use of appropriate visual media is essential to build deep understanding. The lack of concrete visualization media limits students' exploration and knowledge construction in understanding projection concepts.

These comprehension difficulties directly impact students' academic achievement. Grade recapitulation shows an average achievement of only 3.0, far below the graduation standard, as presented in Figure 1. This low learning outcome indicates weaknesses in mastering basic concepts that should be acquired at the early stage of art education. Sibarani [5] explains that students with low self-efficacy tend to lack confidence in facing academic tasks, including technical tasks such as projection drawing, which ultimately affects learning outcomes. When motivation, conceptual understanding, and self-efficacy are simultaneously at low levels, the learning process cannot proceed optimally and requires innovation in media and more effective instructional strategies.

This issue is further confirmed through the perspective of institutional leaders. Field findings were reinforced through interviews with the Head of the Study Program (May 29, 2024) and the Head of the Department of Art and Design (May 2, 2024). Both revealed that the limited innovation in digital learning media is one of the main factors behind the low effectiveness of learning. This is ironic considering that current art students belong to the digital native generation. According to Carolina [13], individuals born in the digital era tend to learn through fast, interactive, and visual media. Therefore, instructional approaches that fail to accommodate these characteristics will create obstacles in content delivery, student engagement, and conceptual understanding.

In this context, the use of Augmented Reality (AR) technology emerges as a potential solution. AR enables the integration of the real world and three-dimensional virtual objects in real time, providing a more immersive, concrete, and interactive learning experience. Darmawan [20] shows that the use of appropriate learning media can significantly increase motivation, interest, and understanding of material. Through AR, students can observe 3D object models, manipulate viewing angles, and understand the relationship between three-dimensional objects and their two-dimensional representations. Yoga and Tegeh [21], in their recent study, developed a 3D Augmented Reality media based on animated video for elementary science learning, which proved effective in improving students' conceptual understanding, with an increase of up to 42% compared to conventional learning. This finding is highly relevant to Projection Drawing learning, which also requires 3D visualization to build conceptual understanding.

Patiro [17] and Setiawan [22] emphasize that AR technology can increase student engagement and provide a more enjoyable learning experience. Furthermore, AR enables flexible learning as it can be accessed through mobile devices. This flexibility aligns with current students' learning patterns, which require fast access and user-friendly media in various situations, including outside the classroom. Thus, AR has the potential to overcome visualization constraints and encourage active student participation. Darmawan [23] developed augmented reality media to improve conceptual understanding and biomotor skills in traditional Balinese games, demonstrating that AR is not only effective for conceptual learning but also for psychomotor skill development—an aspect that is highly important in Projection Drawing learning.

The potential of AR in education is supported by various recent research findings. A study by Akçayır and Akçayır in Trisnawati [24], in their meta-analysis of 68 studies, identified that AR consistently improves content understanding, learning motivation, and student engagement across various educational fields. In the context of technical and visual learning, Cheng and Tsai in Harahap [25] found that AR effectively improves students' spatial ability, which is highly relevant to projection drawing learning. Furthermore, research by Ibáñez and Delgado-Kloos in Yuhelman [26] shows that AR-based learning results in better knowledge retention compared to conventional methods due to more concrete and contextual learning experiences.

However, the presence of technology alone is not sufficient to ensure learning success. Media must be integrated into a learning model oriented toward student activity. Among various learning models, Project-Based Learning (PjBL) is highly relevant for art education. PjBL emphasizes problem-solving processes through project activities requiring critical, creative, and collaborative thinking skills. Riyanti [27] shows that PjBL can enhance creativity and students' achievement motivation. Through PjBL, students not only understand concepts theoretically but also apply them in real projects relevant to the field of art.

The effectiveness of PjBL in education has been well documented. Research by Kokotsaki, Menzies, and Wiggins in Nu'man [28] identified that PjBL improves students' critical thinking skills, collaboration, and learning independence. In the context of art and design education, research by English and Kitsantas (2013) shows that PjBL provides authentic contexts for students to develop technical and creative skills simultaneously. A meta-analysis study by Chen and Yang [29] found that PjBL significantly improves intrinsic motivation and learning outcomes across various educational levels, with larger effect sizes in learning involving technical and spatial skills. Suastra (2017) proved the effectiveness of the PjBL model with authentic assessment in junior high school science learning to develop critical thinking, scientific attitudes, and student self-efficacy. Furthermore, study [30] shows that the implementation of PjBL increases students' learning independence and critical thinking skills, with significant improvement in both variables ($p < 0.001$).

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The importance of integrating AR with PjBL is further strengthened by research findings examining their synergy. Sandra [31] showed that integrating AR into project-based learning significantly improves students' problem-solving skills and learning motivation in STEM subjects. Lin [32] found that the combination of AR and PjBL creates a more immersive and collaborative learning environment, encouraging students to engage more actively in exploring abstract concepts.

Findings from various needs analysis studies align with the real conditions observed by the researcher in the field. Initial observations conducted on students of the Art Education Study Program at UNDIKSHA show patterns consistent with international literature. The results of a learning needs questionnaire administered to 34 students revealed that 82.4% experienced difficulty visualizing the transformation of 3D objects into 2D representations in projection drawing, a figure very close to Saltan and Arslan's (2021) finding of 85%. Furthermore, 88.2% of students stated that conventional learning media (whiteboards and 2D handouts) were insufficient to help them understand orthogonal, isometric, and perspective projection concepts. In terms of technology preference, 91.2% expressed very high interest in AR-based learning, with 85.3% specifically stating the need for media that allows real-time manipulation of 3D objects to understand various projection angles. Regarding learning models, 79.4% preferred more active, project-based approaches rather than lectures and passive demonstrations. Most significantly, 86.8% stated that they needed learning media accessible flexibly via smartphones, both inside and outside the classroom, confirming the characteristics of digital natives [13]. These observational data not only confirm international literature findings but also provide strong empirical justification that the development of AR-based PjBL media is not merely a technological innovation but a direct response to students' real needs identified through both global studies and local conditions at UNDIKSHA.

Based on these theoretical and empirical foundations, the integration of AR and PjBL has great potential to provide meaningful learning. AR helps present object visualization in real three-dimensional form, while PjBL facilitates students in developing that understanding through creative projects. This integration is expected to enhance learning motivation, strengthen conceptual understanding, and improve student learning outcomes. In addition, this approach aligns with the characteristics of digital native students who are more interested in technology- and visual-based learning experiences [13].

From observations, interviews, document analysis, and literature review, it can be concluded that the main problems in Projection Drawing learning include low student motivation, low understanding of projection concepts, and low learning outcomes in this course.

The absence of Augmented Reality learning media with a Project-Based Learning approach within the Department of Art and Design at UNDIKSHA gives this research significant novelty value. This study not only aims to develop learning media but also to provide theoretical contributions regarding the integration of AR and PjBL in the context of

art education. Ultimately, the use of AR-based PjBL is expected to provide a more effective, interactive, and meaningful learning experience, thereby improving the quality of learning and student outcomes in the Projection Drawing course. This research is expected to continue and expand the tradition of innovative PjBL-based learning media development pioneered by previous researchers, with the addition of an AR technology dimension that has never previously been implemented in the Department of Art and Design at UNDIKSHA.

2. RESEARCH METHOD

This study employed a Research and Development (R&D) approach using the 4D development model, which consists of Define, Design, Develop, and Disseminate stages [23]. The research subjects were 22 students from the Art Education Study Program at Ganesha University of Education. This development model was chosen due to its systematic structure in producing quality educational products [33].

In the Define stage, a needs analysis was conducted through observations, interviews, and preliminary questionnaires to identify problems in Projection Drawing learning. The Design stage involved designing the AR-based PjBL instructional media, developing learning materials, and designing the application interface. The Develop stage included content expert validation, media expert validation, individual trials, small group trials, and field testing. The Disseminate stage was carried out through the implementation of the media in PjBL-based learning activities.

The research instruments consisted of expert validation sheets, learning motivation questionnaires, and learning outcome tests (pretest–posttest). Data analysis was conducted using descriptive quantitative analysis, the Wilcoxon Signed Rank Test to analyze changes in learning motivation, and N-Gain analysis to measure improvements in learning outcomes.

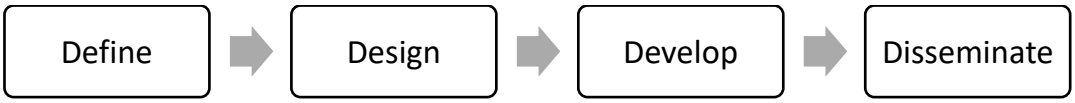

Figure 2. The 4-D Development Model is adapted from Thiagrajan, Semmel, and Semmel modified

3. RESULTS AND DISCUSSION

This section explains the research results and, at the same time, a comprehensive discussion. Results can be presented in figures, graphs, tables, and others that make the reader understand easily [7]. The discussion can be made in several sub-sections.

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3.2. Define

The results of the needs analysis showed that students require more interactive media. This is in line with the view that the school environment and the availability of learning facilities significantly influence student learning outcomes [22]. Therefore, innovative media is needed that can transform abstract information into more concrete visual representations [32]

3.3. Design

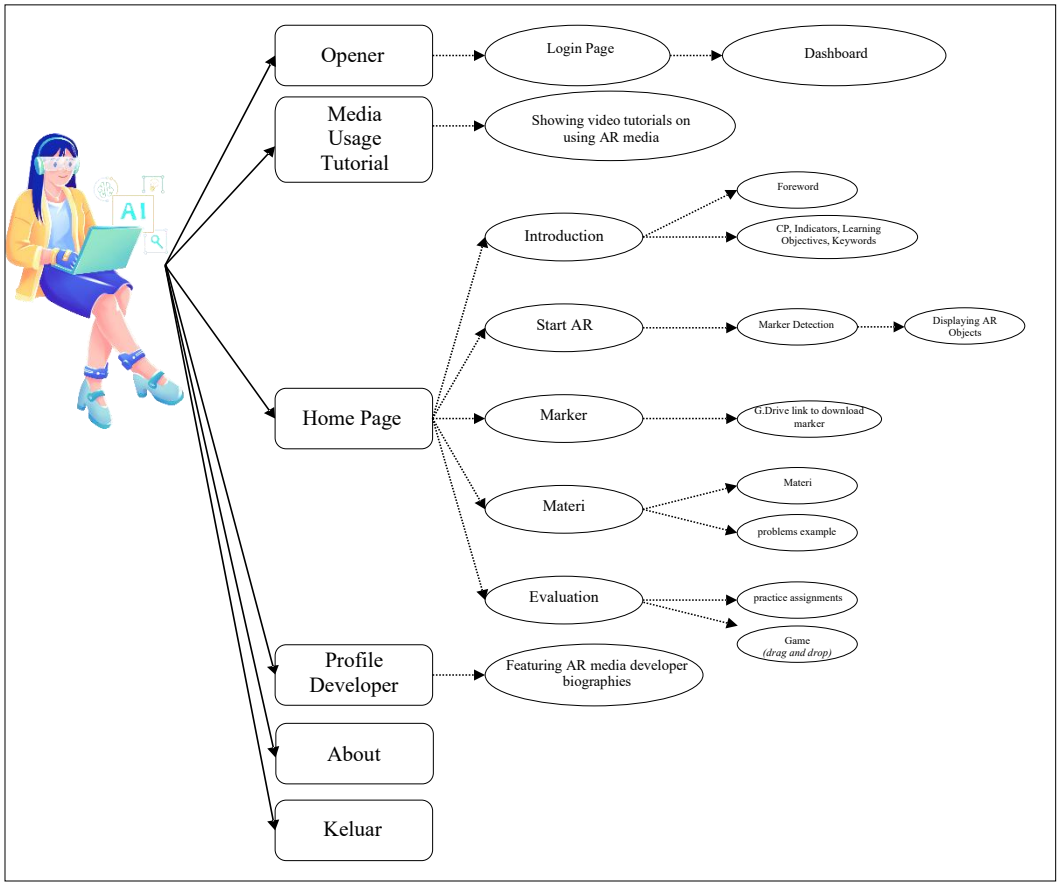

Figure 3. Flowchart of Material on Media as a whole

The Augmented Reality (AR) product developed in this research is a mobile-based learning application designed to help students understand spatial concepts and three-dimensional (3D) representations in the Projection Drawing course. This application can display 3D objects in real time when the device's camera is pointed at specific markers, allowing students to manipulate, rotate, zoom, and observe visual forms more concretely.

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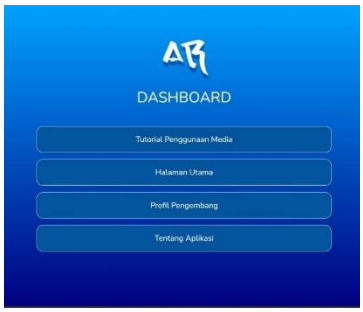
In this design, the aspect of usability was a top priority so that students could focus on the learning content [16]

Pedagogically, this AR supports project-based learning (PjBL) by allowing students to conduct initial observations of 3D objects as a basis for planning and completing project assignments. Thus, AR media serves as a bridge between 2D image representations and 3D spatial understanding.The integration of AR with the PjBL model created a more active and collaborative learning environment. Students were directly involved in exploring 3D objects, planning projects, and reflecting on learning outcomes. This supports the Experiential Learning theory, which emphasizes learning through concrete experiences [11].

(a)



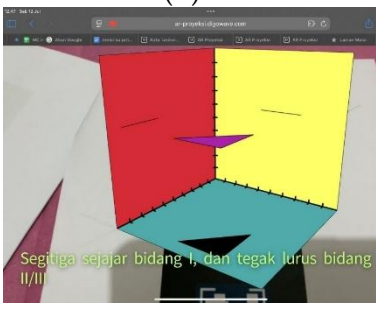
(b)

(c)

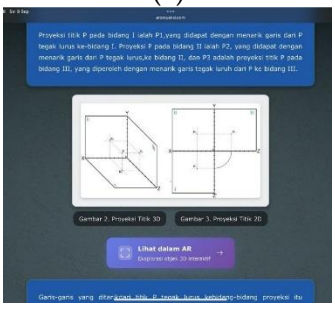
(d)

(e)

(f)



(g)



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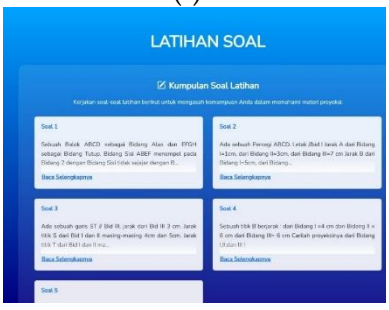

(i)

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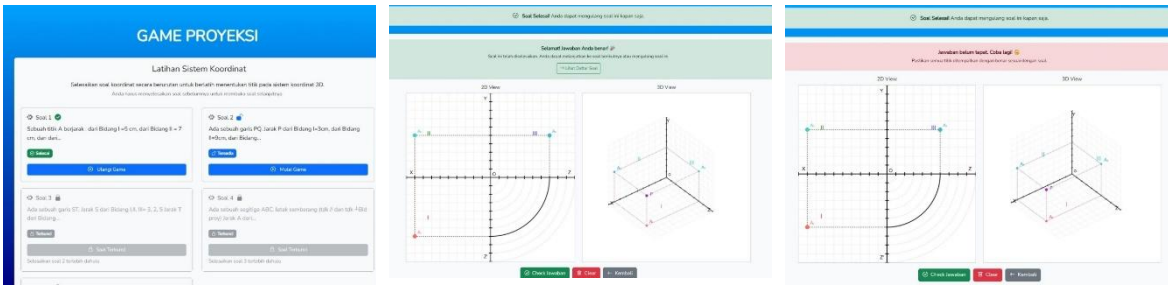

(j) (k) (l)

Figure 4. (a) Login, (b) Dashboard, (c) Media Usage Tutorial, Main Page, Developer Profile, and About the Application, (d) Main Page, (e) Introduction, (f) Marker, (g) Start AR, (h) Material, (i) Practice Questions, (j) Game Questions, (k) Correct Answers, (l) Wrong Answers

3.4. Develop

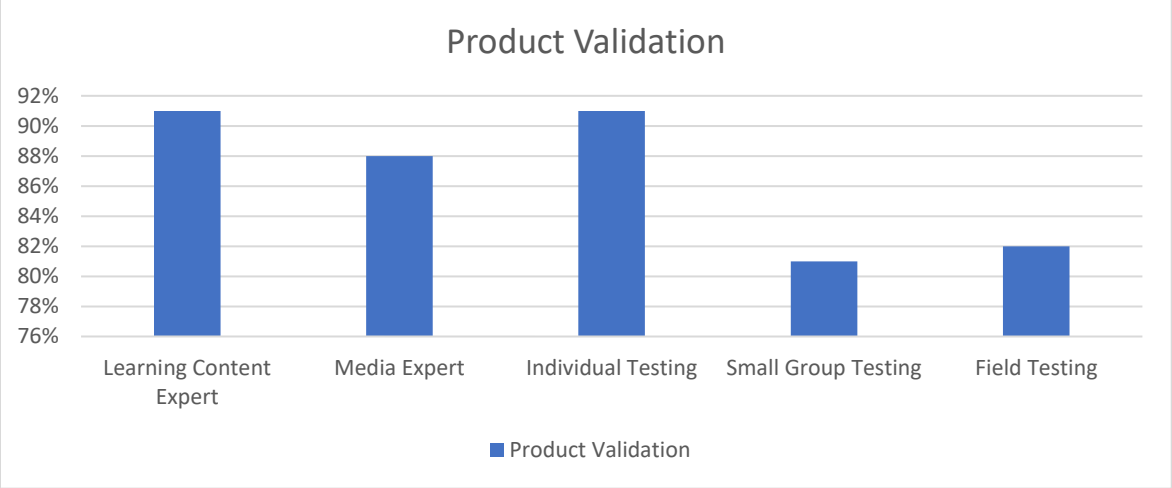

Figure 5. Product Validity

The results of the material expert validation showed a feasibility percentage of 91%, and the media expert validation reached 88%. These figures indicate that the developed AR learning media is highly feasible for use [34]. Furthermore, the development of this media also considered pedagogical aspects in science and art learning [35].

3.5. Disseminate

3.5.1. Effectiveness on Learning Outcomes

Table 1. Output SPSS Uji N-Gain

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation

Pretest	22	26	57	41.00	7.728
Posttest	22	66	82	72.41	4.339
Ngain_Secore	22	.21	.66	.5232	.11109
Ngain_Persen	22	20.93	66.22	52.3193	11.10889
Valid N (listwise)	22				

The analysis of learning outcomes showed a significant increase from the pretest mean score (41.00) to the posttest mean score (72.41). The N-Gain value of 0.52 falls into the moderate category, indicating that the AR instructional media is effective in improving students' understanding of projection drawing concepts. This finding is consistent with the Cognitive Theory of Multimedia Learning, which states that three-dimensional visualization supports the integration of verbal and visual information [13].

The effectiveness of the AR media was proven by the increase in learning outcomes (N-Gain 0.52) and significant learning motivation [17]. The use of games within AR also provides a new perspective for students in understanding material physically and cognitively [22]. Socializing the use of AR content within the educational environment is an important step for the sustainability of this innovation [36].

3.5.2. Improvement of Learning Motivation

Table 2. Output SPSS Uji N-Gain

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-48,045	5,827	1,242	-50,629	-45,462	-38,676	21	,000

The results of the Wilcoxon test indicated a significant difference in learning motivation before and after the use of AR instructional media ($p < 0.05$). The AR media was able to attract students' attention, increase learning relevance, build confidence, and provide learning satisfaction, in accordance with the ARCS motivation model [13].

4. CONCLUSION

The Project-Based Learning–based Augmented Reality instructional media developed in this study is proven to be valid, practical, and effective in improving students' motivation and learning outcomes in the Projection Drawing course. This media facilitates

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concrete spatial visualization, enhances student engagement, and supports meaningful project-based learning.

Project-Based Learning–based Augmented Reality instructional media has proven to be valid and effective [22]. This technology not only improves learning outcomes but also helps students master spatial concepts in Projection Drawing in a more enjoyable and interactive way [37].

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