Elementary School Teachers' Perceptions of Augmented Reality Learning Media through Assemblr Edu

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Abstrack

The development of digital technology has brought significant changes in education, particularly in how teachers teach and students learn. One innovation increasingly applied is Augmented Reality (AR) technology through the Assemblr Edu platform. This study aims to analyze elementary school teachers' perceptions of using AR-based learning media via Assemblr Edu and to identify supporting and inhibiting factors in its implementation. Using a descriptive qualitative approach, data were collected through in-depth interviews, observation, and documentation involving eight elementary school teachers in Karawang Regency who participated in Assemblr Edu training. The results show that 75% of teachers perceived AR media as very effective in increasing students' motivation and facilitating understanding of abstract concepts, especially in science and mathematics lessons. Teachers stated that the 3D visualization features enhanced student engagement and comprehension. However, limited infrastructure, especially unstable internet access in schools located in the outskirts of Karawang, remains a key barrier. Teachers emphasized the need for continuous mentoring and hands-on workshops to strengthen their ability to create AR-based learning materials. The findings highlight Assemblr Edu's potential as an innovative medium that supports teacher professionalism and digital literacy. These results can serve as a basis for regional policies on teacher-training programs that integrate AR technology into elementary education.
Keywords: augmented reality, teacher perception, learning media, teacher professional development

Abstrak

Perkembangan teknologi digital telah membawa perubahan signifikan dalam pendidikan, terutama dalam cara guru mengajar dan siswa belajar. Salah satu inovasi yang semakin diterapkan adalah teknologi Augmented Reality (AR) melalui platform Assemblr Edu. Penelitian ini bertujuan untuk menganalisis persepsi guru SD tentang penggunaan media pembelajaran berbasis AR melalui Assemblr Edu dan untuk mengidentifikasi faktor pendukung dan penghambat dalam implementasinya. Dengan menggunakan pendekatan kualitatif deskriptif, data dikumpulkan melalui wawancara mendalam, observasi, dan dokumentasi yang melibatkan delapan guru SD di Kabupaten Karawang yang mengikuti pelatihan Assemblr Edu. Hasil penelitian menunjukkan bahwa 75% guru menganggap media AR sangat efektif dalam meningkatkan motivasi siswa dan memfasilitasi pemahaman konsep abstrak, terutama dalam pelajaran sains dan matematika. Guru menyatakan bahwa visualisasi 3D menampilkan peningkatan keterlibatan dan pemahaman siswa. Namun, infrastruktur yang terbatas, terutama akses internet yang tidak stabil di sekolah-sekolah yang terletak di pinggiran Karawang, tetap menjadi penghalang utama. Guru menekankan perlunya pendampingan berkelanjutan dan lokakarya langsung untuk memperkuat kemampuan mereka dalam membuat materi pembelajaran berbasis AR. Temuan tersebut menyoroti potensi Assemblr Edu sebagai media inovatif yang mendukung profesionalisme guru dan literasi digital. Hasil ini dapat menjadi dasar kebijakan daerah tentang program pelatihan guru yang mengintegrasikan teknologi AR dalam pendidikan dasar.
Kata kunci: *augmented reality, persepsi guru, media pembelajaran, pengembangan profesi guru*

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INTRODUCTION

The rapid development of information and communication technology (ICT) in the 21st century has brought about significant changes in various sectors of life, including education. Education in the Industrial Revolution 4.0 era requires students to possess critical, creative, collaborative, and communicative thinking skills, supported by digital literacy (Kemdikbudristek, 2022). Therefore, teachers, as learning facilitators, need to adapt to technological developments to create innovative, interactive, and meaningful learning experiences for students.

One technological innovation widely used in education is Augmented Reality (AR). AR technology integrates the real world with interactive three-dimensional virtual elements via digital devices such as smartphones or tablets (Supriyanto et al., 2023). In the context of elementary education, AR can help students understand abstract concepts in a more visual, realistic, and engaging way. For example, in science or mathematics lessons, students can learn about geometric shapes or human organs directly in interactive 3D forms (Wijayanti & Fitriyah, 2022).

One popular and easily accessible platform for teachers is Assemblr Edu, an AR-based application that allows users to create, display, and share learning content in three-dimensional formats in a simple way (Assemblr Edu, 2023). The use of this application among teachers in Indonesia continues to increase, supported by various digital literacy and AR-integration training programs conducted by schools, educational communities, and local education offices (Sinensis et al., 2022). Through Assemblr Edu, teachers can create more engaging learning media, foster student curiosity, and increase their engagement in the teaching and learning process (Sari & Prasetyo, 2021).

Despite the growing interest in AR-based learning media, existing research on AR implementation in Indonesia mostly focuses on student learning outcomes, student motivation, or the development of AR learning products, while teachers' perspectives, especially in elementary schools, remain underexplored. Previous studies emphasize the benefits of AR for students but do not examine teachers as the main implementers who determine the success of AR-based learning. In addition, most recent AR studies are conducted in urban schools with adequate digital infrastructure, leaving limited understanding of teachers' experiences in semi-urban and rural areas where technological readiness remains uneven. This creates both an empirical and contextual research gap that requires further investigation.

However, research on AR implementation in Indonesia mainly focuses on student learning outcomes, while teachers' perspectives, especially in public elementary schools, are still less explored. Some studies have highlighted the benefits of AR for student motivation Yusa et al., (2023), but they do not deeply investigate teachers' perceptions as the main implementers of digital learning.This research fills that gap by focusing on teachers in Karawang district, an area that actively promotes digital education through local government programs, but still faces gaps in technology infrastructure and digital literacy among educators. The local urgency of this research lies in understanding how teachers in semi-urban and rural contexts perceive the practicality and usability of AR-based learning media.

Assemblr Edu is one of the most popular AR-based platforms among teachers in Indonesia (Kurniawan et al., 2023). This platform allows teachers to easily create and share interactive 3D content, aligning with the goals of digital learning transformation. However, teachers' adoption of Assemblr Edu is highly dependent on their perceptions of usefulness and ease of use two constructs derived from the Technology Acceptance

Model (TAM) (Davis, 1989). Furthermore, effective AR integration requires teachers' Technology Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006), which links technology skills with pedagogical and content knowledge. Understanding how TAM and TPACK interact provides a stronger theoretical foundation for analyzing teachers' readiness for digital learning.

Therefore, this study aims to explore elementary school teachers'perceptions of the usefulness and ease of using AR-based learning media through EAssemblr edu, as well as to identify the supporting and inhibiting factors influencing its implementation in Karawang Regency. Specifically, this research seeks to answer the following question, How do elementary school teachers perceive the benefits and ease of using assemblr edua as a learning medium based on Augmented Reality?

METHOD

This research employed a qualitative approach with descriptive methods. This approach was chosen because it provides an in-depth and holistic description of teachers' perceptions of the use of Augmented Reality-based learning media through Assemblr Edu. Qualitative research seeks to understand the meanings behind human behavior and experiences in natural contexts. Meanwhile, descriptive methods aim to systematically present field-based facts without manipulating the variables under study (Sugiyono, 2022).

This research was conducted in several public elementary schools in Karawang Regency, West Java, that are familiar with or use Augmented Reality-based learning media, specifically Assemblr Edu. Locations were selected using a purposive sampling approach, targeting schools with teachers actively using digital learning technology. The research was conducted from May to July 2025, encompassing preparation, data collection, analysis, and report preparation.

The subjects in this study were elementary school teachers who had used or participated in training related to the Assemblr Edu application. Informants were selected using a purposive sampling technique, selecting informants based on specific considerations such as experience, involvement, and ability to use technology-based learning media. The number of informants in this study was 5 to 8 teachers from several elementary schools to obtain a wider range of perceptions.

Data collection techniques included in-depth interviews, observation, and documentation. Semi-structured interviews explored teachers' experiences, perceptions, and challenges in using Assemblr Edu. Observations were conducted to directly observe learning activities using AR, while documentation collected additional data in the form of activity photos, teaching materials, and field notes. These three techniques were used triangulationally to ensure the data obtained was more valid and accurate.

Data analysis was conducted interactively and continuously from data collection to drawing conclusions. The analysis process followed the model of Miles, Huberman, and Saldaña (2014) which includes three stages: (1) data reduction, (2) data presentation, and (3) drawing conclusions and verification. Data reduction involved selecting and simplifying relevant data; data presentation was in the form of descriptive narratives and thematic matrices; and conclusions were drawn by interpreting the meaning of the categorized data.

To ensure data validity, researchers used source and technique triangulation, comparing interview results, observations, and documentation from various informants. Furthermore, member checking was conducted to ensure that the data obtained aligned

with the informants' perspectives. Researchers also conducted an audit trail by recording the entire research process to demonstrate transparency and accountability of the research results (Carcary, 2020).

RESULTS AND DISCUSSION

Results

Interview results indicate that all respondents had a positive perception of the use of digital technology in the learning process. Teachers considered technology to play a crucial role in facilitating the delivery of material, enriching learning resources, and increasing student engagement during teaching and learning activities. Through technology, teachers can present a variety of more engaging and interactive learning media, such as videos, animations, and educational applications tailored to student characteristics. This indicates that teachers are shifting from conventional learning approaches to student-centered digital learning models.

A total of eight elementary school teachers participated as informants in this study. They were selected based on their teaching experience and involvement in Assembler Edu training programs.

Table 1.
Shows the Complete List of Informants

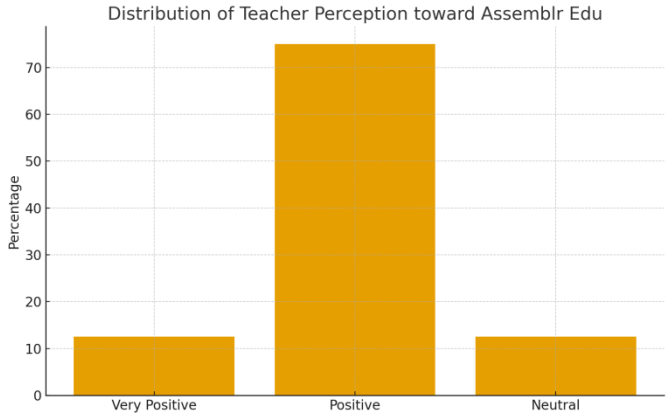
Teacher Code	Teaching Experience	School Location	Experience Using Assemblr Edu
T1	5 Years	State Elementary School 1 Karawang	Attended training and implemented it in lessons
T2	3 Years	State Elementary School 2 Karawang	Used it for IPS learning
T3	6 Years	State Elementary School 3 Karawang	Began designing AR-Based Learning Media
T4	4 Years	State Elementary School 4 Karawang	Participated in basic AR training
T5	5 Years	State Elementary School 5 Karawang	Applied Assemblr Edu in Mathematics
T6	6 Years	State Elementary School 6 Karawang	Used AR media in project based learning
T7	3 Years	State Elementary School 7 Karawang	In the process of integrating AR into lesson plans
T8	4 Years	State Elementary School 8 Karawang	Introduced AR in science class

Based on the coding and categorization process, several major themes emergad that describe teachers’perceptions of Assemblr Edu’s use in elementary learning. Thematic analysis was conducted using Miles and Huberman's (2014) model, consisting of data reduction, data display, and conclusion drawing.

Table 2.
Thematic Mapping Results Based on Miles & Huberman Model (2024)

Theme	Description	No.Of Information	Percentage	Code Reference
Positive perception of digital technology	Teachers considered technology to enhance student motivation and learning engagement	6	75%	T1,T2,T4,T5,T6,T8
Perceived ease of use	Assemblr Edu was easy to use after hands-on training	5	63%	T1,T2,T5,T6,T7
Infrastructure barriers	Limited internet access and devices	6	75%	T3, T4, T5, T6, T7, T8
Need for continuous training	Teachers emphasized ongoing mentoring	7	88%	T1-T7
Improvement of professionalism and creativity	Ar media encouraged innovation and reflective teaching practices	6	75%	T1, T2, T4, T5, T6, T7

Graph 1.
Distribution of Teacher Perception toward Assemblr Edu



Graph 1 shows the distribution of perceptions among elementary school teachers in Karawang regarding the use of Augmented Reality-based learning media through the

Assemblr Edu platform. The majority of teachers (75%) had positive perceptions, indicating that AR applications are considered to provide real benefits to the learning process. They assessed that the 3D visual features on Assemblr Edu help increase student motivation and facilitate understanding of abstract material, especially in subjects such as science and mathematics.

A total of 12.5% of teachers have a very positive perception, indicating that a small number feel this technology is not only useful but also very effective in creating more interactive learning and increasing student participation. Teachers in this group are usually more technologically ready or have more experience creating AR content.

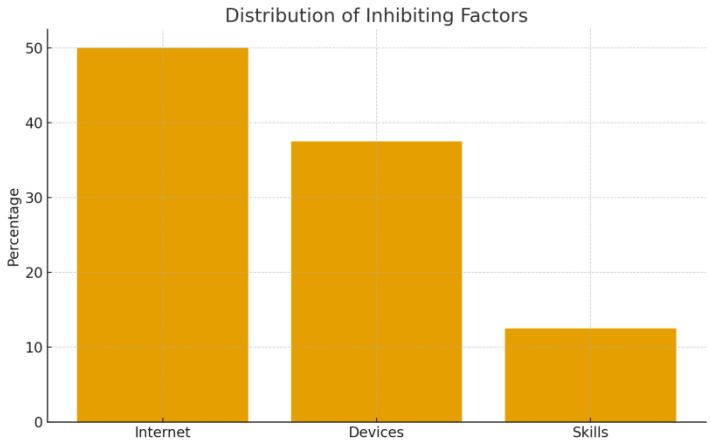
Meanwhile, 12.5% of teachers expressed neutral perceptions. This group has not yet felt a significant impact from using Assemblr Edu in learning. This may be due to infrastructure limitations, insufficient training, or limited time to fully explore the application's features.

Based on interviews, the majority of teachers reported being first introduced to Augmented Reality (AR) technology through training on the Assemblr Edu app. This first experience was a pivotal moment that fostered high enthusiasm for AR-based learning innovations. The teachers acknowledged that this medium broadened their horizons by offering new ways to deliver material in an immersive, contextual way. Teachers noted that Assembl Edu was easy to operate after hands-on training and practice-based workshop

Although teachers demonstrate positive attitudes, research also reveals major obstacles to implementing digital technology in elementary schools. Frequent obstacles include limited internet access, a lack of digital devices such as projectors and laptops, and a lack of technical skills in operating digital media. This situation indicates that teacher readiness is still at the introductory stage and has not yet reached optimal utilization.

The TPACK model emphasizes integrating technological, pedagogical, and content knowledge to enable teachers to design effective digital learning experiences. In this context, teachers with a strong understanding of content and learning methods will more easily adapt AR technology as a relevant and meaningful supporting medium.

Graph 2.
Distribution of Inhibiting Factors



Graph 2 illustrates the distribution of obstacles experienced by teachers in implementing AR-based learning media through Assemblr Edu. The main obstacle most

commonly experienced by teachers is internet connectivity, at 50%. This shows that network stability remains a major challenge in the use of AR in schools. Dependence on a strong network makes AR learning difficult to run optimally, especially for schools in rural areas.

The second inhibiting factor is device limitations at 37.5%. Some schools have not fully provided the necessary support devices, such as adequate computers, projectors, or compatible software. This condition prevents the comprehensive implementation of AR-based learning, forcing teachers to find other alternatives for delivering material.

The third factor is teachers' skills in operating technology, which accounts for 12.5%. This shows that a small number of teachers still feel unsure about using AR devices. The lack of advanced technical training and guidance has prevented teachers from maximizing the potential of AR in the classroom.

Theoretically, these three barriers are related to the External Variables aspect of the TAM model and the Technological Knowledge (TK) dimension of the TPACK model. Infrastructure and device barriers are external factors that affect perceived ease of use, whereas limitations in teacher skills relate to technological mastery, which is part of TPACK.

Table 3.
Integration of field findings with TAM and TPACK Frameworks

Field Findings	Related Theory	Explanation
Positive perception of technology's benefits	Perceived Usefulness (TAM)	Teachers acknowledged that AR improves learning effectiveness and student engagement.
Ease of use and accessibility	Perceived Ease of Use (TAM)	Teachers found *Assemblr* Edu easy to operate after practical training.
Integration into lesson design	TPACK Integration	Teachers with strong pedagogical and content knowledge could align AR media with learning objectives.
Increased creativity and professionalism	TPACK Competence Development	AR encouraged teachers to innovate, reflect, and enhance digital pedagogy.

Therefore, teacher professional development programs need to be integrated into Continuous Professional Development (CPD) policies to ensure the sustainability of teachers' digital competencies. The findings highlight *Assemblr Edu* as a promising educational innovation to enhance both digital literacy and teaching professionalism among elementary school educators.

Discussion

This opinion aligns with the views of Teachers Yuyun and Rusdi, who stated that technology helps make the delivery of learning material more efficient and engaging. Teachers also find digital media beneficial because it can clarify abstract concepts and save time in presenting content. This finding is consistent with recent studies showing that integrating digital technology can enhance students' learning motivation while

simultaneously strengthening teachers' digital pedagogical competence (Rosyidah et al., 2025). These positive perceptions indicate that teachers no longer view technology as an additional supporting tool, but rather as an essential component of effective 21st-century learning practices.

In addition to technical constraints, teacher readiness is also influenced by organizational support and school culture. Research by Li et al. (2021) confirms that technology acceptance is influenced by perceptions of external control and institutional support. This means that the success of digital transformation is determined not only by individual teacher abilities but also by systemic support such as school policies, training time, and the provision of facilities. Therefore, teacher readiness needs to be understood comprehensively as the result of interactions among personal, technical, and structural factors (Aisyah et al., 2022).

Teachers emphasized the importance of practical and ongoing advanced training. They argued that theoretical training alone was insufficient to support Assemblr Edu's implementation in the classroom. Teachers needed hands-on guidance on creating simple AR projects, integrating digital content into Lesson Plans (RPPs), and digital media-based evaluation strategies.

An effective training model is a hands-on workshop accompanied by ongoing mentoring. According to Teacher Dendi, ideal training should not be conducted once but should also include follow-up sessions to ensure optimal implementation in the field. This approach aligns with the principles of Adult Learning Theory (Knowles, 1980), which emphasize that adult learning is effective when grounded in direct experience and relevant to workplace needs. Research by Raharjo et al. (2022) confirms that hands-on experience-based training improves teachers' ability to utilize learning technology. Therefore, teacher professional development programs need to be integrated into Continuous Professional Development (CPD) policies to ensure the sustainability of teachers' digital competencies.

All informants stated that the use of Assemblr Edu has had a positive impact on improving teacher professionalism and creativity. AR media encourages teachers to think more innovatively, design contextualized learning experiences, and adapt their approaches to the characteristics of the digital generation. Teachers feel more motivated to use technology as part of their professional development.

According to Teachers Rusdi and Yuyun, Assemblr Edu offers teachers opportunities to be creative and create engaging, relevant digital teaching media. This aligns with UNESCO's (2022) statement that mastery of digital technology is part of teachers' professional competence in the era of educational transformation. Research by Prasetya et al. (2023) also shows that the use of digital technology encourages increased creativity, collaboration, and reflective skills in teachers during the learning process. Thus, Assemblr Edu has the potential to become a tool for strengthening teacher professionalism based on digital innovation.

This finding aligns with the Technology Acceptance Model (TAM) theory proposed by Davis (1989), which states that user acceptance of technology is influenced by two main dimensions: perceived usefulness and perceived ease of use. In the context of this study, teachers reported that digital technology provided tangible benefits, increasing the effectiveness and efficiency of learning. However, perceived ease of use was still influenced by limited infrastructure and technical support.

Recent research by Huang et al. (2022) and Yusof & Ariffin (2023) confirms that perceived ease and usefulness are strong predictors of teachers' intention to adopt

technology in learning. Thus, even if teachers have positive perceptions, successful technology adoption remains highly dependent on external factors such as managerial support, relevant training, and a conducive work environment.

Teachers believe that AR's primary advantage lies in its ability to display interactive, realistic 3D objects, enabling students to learn in a more visual, concrete way. For example, in science lessons, students can explore the structure of the Earth, human organs, or geometric shapes in 3D that can be rotated and enlarged. These visualizations help students understand abstract concepts that are difficult to explain verbally. These findings align with those of Bacca et al. (2021) and Akçayır & Akçayır (2022), who demonstrated that AR increases student engagement, conceptual understanding, and learning motivation through engaging visual interactions.

Although teachers have shown a high interest in AR, its implementation remains hampered by limited facilities and digital connectivity. Some schools lack supporting devices, while students' use of personal devices remains limited. This situation highlights a gap between technological readiness and adoption capacity at the educational unit level. Therefore, teacher training should focus not only on technical application mastery but also on pedagogical strategies relevant to school conditions.

Teachers can utilize collaborative approaches, such as project-based learning, where students work in small groups using a single device to learn material together. This strategy not only overcomes facility limitations but also strengthens students' collaboration and social skills. Consistent with the findings of a meta-analysis by Santos et al. (2023), the effectiveness of AR in learning is strongly influenced by the implementation context and the pedagogical support provided by teachers. Therefore, teachers need to play an active role in adapting the use of AR to student characteristics and school resources.

Most respondents found Assemblr Edu effective in helping students understand complex and visual material. The app's interactive 3D features enhance student learning and help teachers explain abstract concepts. Teachers also found that using this tool creates a more contextual and meaningful learning experience because students can interact directly with the learning materials.

However, some teachers still encounter challenges adapting teaching content to digital media formats. Teacher Dendi mentioned that it takes time to adapt the material to Assemblr Edu's interactive visual needs. This suggests that the success of learning media depends not only on technological factors but also on the teacher's pedagogical ability to integrate the media effectively. A meta-analysis by Garzón & Acevedo (2022) concluded that AR generally improves learning outcomes, but its effectiveness depends on teacher preparedness and learning design.

The findings of this study also relate to the concept of Technological Pedagogical Content Knowledge (TPACK) proposed by Mishra and Koehler (2006). Recent research by Hidayat et al. (2023) and Fitriani and Arifin (2021) shows that a high level of TPACK mastery significantly impacts teachers' ability to develop creative digital media. Therefore, TPACK-based training is a crucial step in strengthening teachers' digital literacy. This competency enhancement will ensure that technologies like Assemblr Edu are used not only as visual aids but also as strategic learning media that support the achievement of comprehensive learning objectives.

CONCLUSION

This study concludes that elementary school teachers in Karawang perceive the use of Augmented Reality (AR) through Assemblr Edu as highly beneficial, particularly in helping students understand abstract concepts in science and mathematics and increasing their engagement in learning activities. In relation to the Technology Acceptance Model (TAM) and Technological Pedagogical Content Knowledge (TPACK) frameworks, teachers' acceptance of AR is strong in terms of its perceived usefulness, while perceived ease of use remains limited by inadequate infrastructure, lack of institutional support, and varying levels of digital skills. In practice, these findings highlight the urgent need for continuous, hands-on training and mentoring, as well as improved internet connectivity and the provision of adequate digital devices by schools and local governments, to ensure that AR utilization does not end after initial training. However, this research is limited by its qualitative nature and the small number of informants drawn from a single district, which restricts the generalizability of the results. Future studies are encouraged to employ mixed methods approaches, measure students' learning outcomes, and compare AR implementation across urban and rural schools to gain a broader, more comprehensive understanding of its impact.

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