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Revolutionizing Senior High School Teaching with Augmented Reality-Based Quantum Training

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Abstract

This community service project aims to enhance teachers' pedagogical skills at Rambipuji Jember State High School through training in Quantum Teaching integrated with Augmented Reality (AR). Integrating technology into education is crucial to creating a more interactive and engaging learning environment in today's digital era. Quantum Teaching employs a blend of techniques to boost learning effectiveness, which can deliver a more immersive educational experience when supported by AR technology. The project uses the Participatory Action Research (PAR) method, involving stages that start with an introduction to Quantum Teaching and AR, followed by practical workshops where teachers develop AR-based learning materials aligned with the curriculum. The training also includes evaluation sessions to assess teachers' grasp of the concepts taught. As a result, the teachers' understanding of these innovative teaching methods improved, enabling them to design and implement AR-supported lessons in their respective subjects. This initiative has significantly bolstered the pedagogical competencies of Rambipuji Jember State High School teachers, enhancing the school's capacity to become a model for other institutions in adopting technology-driven teaching strategies. The project's outcomes suggest a broader potential for these approaches to influence educational practices beyond the local context, encouraging continuous advancements in technology-integrated learning.

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INTRODUCTION

Education is a cornerstone of national development, with its quality determined mainly by the caliber of teachers who facilitate the learning process (Marsela et al., 2022). Teachers with strong pedagogical skills and teaching methods are essential in creating effective and engaging educational experiences. At Rambipuji Jember State High School (SMAN Rambipuji Jember), continuous efforts are being made to enhance education quality by improving teachers' pedagogical abilities. Today's educators face increasingly complex challenges due to rapid technological advancements and evolving student learning needs. Traditional teaching methods often struggle to capture students' interest, who are now more inclined toward technology-driven learning experiences (Muzakki, 2022). Hence, innovative teaching approaches are necessary to meet these challenges (Abrar, 2020; Crowther, 1999).

Quantum teaching offers a dynamic approach by integrating various teaching techniques to create an interactive and engaging learning environment (Siregar, 2020). It fosters a positive learning atmosphere, utilizes multiple learning modalities, and connects academic content to students' real-life experiences. Research has demonstrated that quantum teaching can significantly enhance students' conceptual understanding and active participation in the learning process. For instance, studies conducted in elementary schools revealed notable improvements in mathematics and science learning outcomes following the implementation of quantum teaching (Ramadhani & Ayriza, 2019; Rustam & Adli, 2016). Furthermore, Quantum Teaching has proven effective in boosting students' motivation and interest in subjects they previously found difficult or unappealing, especially when combined with technological tools (Fitri et al., 2020; Zaroha, 2019).

Augmented Reality (AR) technology can revolutionize traditional teaching methods by blending digital information with the physical environment in real-time (Arena et al., 2022). AR enables a more immersive learning experience in educational settings, making it easier for students to grasp complex concepts (Amin et al., 2016). For example, AR has been used effectively to teach subjects like anatomy, astronomy, and mathematics, helping students visualize intricate structures and processes that are challenging to understand through text or static images alone (Aslan et al., 2019; Subhashini et al., 2020).

The integration of quantum teaching with AR technology has the potential to create a powerful teaching strategy that enhances both student engagement and learning outcomes. While AR offers a visual and interactive way to present information, quantum teaching principles support creating a learning environment that is enjoyable and conducive to knowledge retention.

This community service initiative aims to train SMAN Rambipuji Jember teachers to develop and implement quantum teaching methods enriched with AR technology. The goal is to enhance teachers' pedagogical skills and encourage creativity in delivering subject content in ways that resonate with today's tech-savvy students.

The training would be structured in several stages, beginning with an introduction to quantum teaching and AR principles, then content creation workshops, and culminating with applying these methods in real classroom scenarios. Each training phase would include hands-on practice and evaluation sessions to ensure teachers effectively adopt and integrate these techniques into their teaching repertoire. Additionally, the training would be supported by the necessary technological tools and resources for AR content creation and usage, empowering teachers to utilize these innovations fully in their lessons.

We anticipate that teachers will gain new skills to create interactive and engaging learning materials through this program. This would enhance their teaching capabilities and provide students with a more stimulating learning experience that aligns with their needs and preferences. The impact of this initiative is expected to extend beyond SMAN Rambipuji Jember, serving as a model for other educational institutions aiming to adopt similar innovative teaching practices.

Adopting new teaching methods is crucial in the face of digital-era educational challenges. The quantum teaching and AR-based training at SMAN Rambipuji Jember represents a proactive step toward elevating educational standards by empowering teachers with the skills to create more relevant and impactful learning experiences.

METHODS

The community service activities were conducted at SMAN Rambipuji Jember using the Participatory Action Research (PAR) method. The activities spanned approximately three

months, from May to July 2024. The main focus was delivering quantum teaching training based on AR for teachers at SMAN Rambipuji Jember. The process included the following stages:

1. Needs Analysis

a) Objective: To understand the current level of teachers' knowledge about quantum teaching and AR and their specific needs in the learning process.
b) Process: The needs analysis was conducted in the first month through an initial survey and teacher interviews. These provided insights into the participants' understanding of quantum teaching, familiarity with AR, and challenges in the learning process.

2. Interviews

a) Purpose: To gather more profound insights into the teachers' experiences, expectations, and obstacles related to the use of technology in education.
b) Details: Selected teachers were interviewed to understand better their perspectives on integrating AR in the classroom.

3. **Training Planning**

a) Activities: The service team developed a structured training plan covering:
b) Quantum teaching theory
c) Basics of Augmented Reality
d) AR content creation
e) Application of AR in classroom settings

4. **Preparation of Training Materials**

Training materials, including presentation slides, practical guides for creating AR content, and example AR applications, were prepared. The AR creation process used the Assemblr EDU application as a primary tool.

5. Training Implementation

a) Timing: Training took place in the second month and was divided into three main sessions: theory, practice, and evaluation.
b) Theory Session: Facilitators explained the core concepts of Quantum teaching and AR. Teachers completed a pre-test to assess their initial knowledge.
c) Presentation Topics:
d) Quantum teaching: An introduction to its principles and benefits for enhancing learning.
e) Augmented Reality: Basics of AR technology, its functionality, and applications in education.
f) Practice Session: Teachers were trained in creating AR-based learning content using Assemblr EDU and conducted a simulation to integrate AR content into their lessons.
g) Evaluation and Discussion Session: Included practical tests (10 multiple-choice questions) and an open discussion to collect feedback and address challenges.

6. Mentoring

a) Duration: Conducted during the third month to provide ongoing support.
b) Activities: Continuous mentoring was provided to assist teachers in implementing AR in their classes. The training team offered guidance on addressing technical issues and enhancing pedagogical approaches.

7. Final Evaluation and Report

a) Evaluation: Conducted a final assessment to evaluate the effectiveness of the training, focusing on improvements in teachers' pedagogical skills and the impact on student learning outcomes.

b) Report Preparation: A comprehensive report detailing the training process, evaluation results, encountered challenges, and recommendations for future improvements was compiled.

RESULTS AND DISCUSSION

Increased understanding of quantum teaching theory and AR can be seen in Table 1.

Table 1 Summary of understanding sg and AR theory by teachers at SMAN Rambipuji

Aspect	Indicator	Pre-Test	Post-Test	Information
Increased Understanding of quantum teaching Theory and AR	Pre-Test Results	20% basic understanding	-	Before training
	Post-Test Results	-	80% good understanding	After training
	Teacher Feedback	30% feel they understand	90% feel they understand	After training

The pre-test results show that only 20% of teachers understand quantum teaching and AR. After training, the post-test results showed significant improvement, with 80% of teachers understanding the basic concepts and principles of quantum teaching and AR. This increase demonstrates the effectiveness of training in increasing teachers' theoretical knowledge. Before the training, only 30% of teachers felt they understood the material. However, 90% of teachers provided positive feedback after training regarding their understanding of the training material. This shows that the training has opened new insights and increased teachers' understanding of innovative teaching methods.

This training introduces the basic principles of quantum teaching, which focuses on creating a positive learning atmosphere, strengthening emotional engagement, and holistic teaching. By understanding this theory, teachers can realize the importance of building strong relationships with students and creating a supportive learning environment. Quantum teaching training integrates a variety of dynamic and creative teaching techniques, such as the use of metaphors, stories, movement, and music, all of which are designed to make the material easier for students to understand and remember (Fitri et al., 2020; Yunus & Rismawati, 2023). These techniques increase the appeal of learning and help teachers convey complex concepts more simply and engagingly (Rustam & Adli, 2016). Through interactive training sessions, teachers are invited to experience how quantum teaching is applied in practice. They are involved in classroom simulations and practical activities where they can develop and try out various innovative teaching strategies. This allows teachers to learn from direct experience and receive constructive feedback, which is critical to their professional development (Zaroha, 2019).

This training is often accompanied by technology, such as Augmented Reality (AR), which enriches the learning experience (Subhashini et al., 2020). Integrating AR in Quantum Teaching training allows teachers to see how this technology can make learning more visual and interactive (Carmigniani et al., 2011). For example, they learn to create and implement AR content that can help students understand abstract concepts through realistic and interactive visualizations (Schmalstieg et al., n.d.). Quantum Teaching training also emphasizes the importance of reflection and evaluation. Teachers are taught to regularly evaluate their teaching methods and look for ways to improve them. By encouraging continuous reflection and adaptation, this training helps teachers to become more innovative and responsive to student needs (Aslan et al., 2019). The training activity ended with the provision of the Quantum Teaching AR book, which can be seen in Figure 1.

Figure 1 End of material delivery session

Mastery of Technical Skills:

Teachers have succeeded in creating AR-based learning content relevant to the curriculum and subjects taught. Table 2 provides summary results.

Table 2 Summary of technical skills

Aspect	Indicator	Pre-Test	Post-Test	Information
Mastery of Technical Skills	AR Content Creation	10% capable	85% capable	Use of AR applications
	Implementation in Class	5% integration	75% integration	Use of AR in subjects

Before the training, only 10% of teachers could create AR-based learning content. After training, 85% of teachers succeeded in creating AR content relevant to the curriculum. Teachers demonstrated significant improvements in technical skills, including AR applications and software. Before the training, only 5% of teachers could integrate AR content in their courses. After training, 75% of teachers successfully implemented AR content in several subjects, such as biology, physics and history. This shows that teachers not only understand AR technology but are also able to apply it effectively in teaching.

Figure 2 Learning activities in class

More Interactive and Engaging Student Learning Experience:

Classroom observations were carried out after the teachers were given training. Observation results show that students participate more actively and are more interested in the material presented using AR. They can more easily understand complex concepts through the visualization provided by AR technology. Learning activities using AR can be seen in Figure 2. A summary of the results can be seen in Table 3.

Classroom observations showed increased active student participation from 20% before AR to 70% after using AR. This increase indicates that AR technology can make learning more interactive and interesting for students. Before the use of AR, only 25% of students found learning interesting. After using AR, 80% of students provided positive

feedback regarding their learning experience. Students feel that learning becomes more interesting and easier to understand with the help of the visualization supplied by AR technology (Pratiwi et al., 2019).

Table 3 Summary of observation results of student learning experiences

Aspect	Indicator	Pre-Test	Post-Test	Information
A More Interactive and Interesting Student Learning Experience	Class Observation	20% active participation	70% active participation	Via AR
	Student Feedback	25% find it attractive	80% find it attractive	After using AR

This technology lets them see three-dimensional representations of the concepts taught, making the material more concrete and intuitive. For example, in a biology lesson, students can view interactive models of organism cells, or in a history lesson, they can explore historical sites virtually (Abdusselam & Karal, 2020). This increases student engagement and strengthens their understanding of the course material. With AR, students can learn through direct and interactive experiences, which makes the learning process more fun and effective (Tarng & Pei, 2023). Student learning experiences in class using AR can be seen in Figure 3.

(a) (b)

Figure 3 (a) Student learning experiences in class and (b) Students use AR in learning

Increasing Teacher Pedagogical Competence:

Teachers feel more confident and creative in designing innovative learning. They can apply Quantum Teaching principles to create a more enjoyable and supportive learning environment. Table 4 summarizes the results of increasing teacher competency.

Table 4. Summary of Increasing Teacher Pedagogical Competence

Aspect	Indicator	Pre-Test	Post-Test	Information
Increasing Teacher Pedagogical Competence	Independent Evaluation	30% feel confident	85% feel confident	Application of Quantum Teaching
	Skills Improvement	25% pedagogical skills	80% pedagogical skills	Motivation, classroom management, method adaptation

Before the training, only 30% of teachers felt confident in designing innovative learning. After the training, 85% of teachers felt more confident and creative in creating a more enjoyable and supportive learning environment. This shows that applying quantum teaching principles has increased teacher confidence in teaching. In addition to technical skills, teachers also reported improvements in their pedagogical skills. Before the training, only 25% of teachers felt they had good pedagogical skills. After training, 80%

of teachers reported improved ability to motivate students, manage the classroom, and adapt teaching methods to suit students' needs. This shows that training improves technical skills and teachers' pedagogical abilities.

Teachers have become more skilled at designing and delivering creative and innovative learning materials and can adapt their teaching methods to meet the needs of diverse students (Gervasi et al., 2023). In addition, this training encourages teachers to apply a more holistic and student-centred approach, which places student needs and involvement as a top priority. As a result, teachers are adept at using technology like AR and more effective at motivating students, managing the classroom, and creating dynamic and supportive learning environments (Levy et al., 2024).

Teachers also conducted satisfaction surveys regarding the team's activities during community service activities. The satisfaction survey showed that the majority of participants were very satisfied with the training provided. They considered the material presented to be very relevant and applicable, as well, and the facilitator was able to provide clear and supportive guidance.

Based on feedback from participants, it is recommended that similar training be held regularly and expanded in scope. In addition, it is recommended that training sessions on other educational technologies that can support the teaching and learning process be added. The results of this activity show that AR-based Quantum Teaching training has significantly improved the quality of learning at Rambipuji Jember State High School. Teachers become more competent and creative in teaching, while students enjoy a more interactive and enjoyable learning experience. Hopefully, this activity can become a model for other schools to utilize technology for better education.

CONCLUSION

The quantum teaching training based on Augmented Reality (AR) at SMA Negeri Rambipuji Jember significantly enhanced teachers' pedagogical and technical skills. Teachers showed a notable improvement in their ability to integrate AR technology into their teaching practices, which resulted in more interactive and engaging learning experiences for students. These positive changes were observed through increased student engagement and better comprehension of the material.

To ensure the long-term success of this initiative, it is essential to continue supporting the teachers with ongoing mentoring and providing the necessary technological infrastructure. Investing in these areas would help sustain the momentum and encourage further innovation in teaching methods.

Looking ahead, SMA Negeri Rambipuji Jember has the potential to serve as a model for other schools to adopt similar strategies to enhance educational quality through technology and innovation. By building on these successes, other academic institutions can follow suit, contributing to a broader transformation in teaching practices that prioritize active learning and technological integration.

This initiative is a step toward creating a learning environment where technology catalyzes continuous improvement. We encourage other schools to consider implementing quantum teaching methods and AR technology, driving the evolution of education toward a more dynamic and student-centered approach.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest related to the content of this article.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, BHS and IW; methodology, BHS; formal analysis, BHS; writing—preparation of the original draft, BHS and IW; review and editing, IW. Authorship is limited to those who have contributed substantially to the reported work.

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