



The Enhancement of Teacher Competency Through Assistance in Creating Augmented Reality-Based Interactive E-Modules at SMAN 10 Palembang

Ida Sriyanti^{1*}, Leni Marlina¹, Agung Mataram², Muhammad Rudi Sanjaya³, Selvia Mariska Syahputri¹, Rahma Dani¹, Muhammad Rama Almafie⁴

¹ Master of Physics Education, Faculty of Teacher Training and Education, Universitas Sriwijaya, Palembang, South Sumatra, Indonesia.

² Master of Mechanical Engineering, Faculty of Engineering, Universitas Sriwijaya, Palembang, South Sumatra, Indonesia.

³ Diploma Informatics Management, Faculty of Computer Science, Indralaya, South Sumatra, Indonesia.

⁴ Doctoral of Mathematics and Natural Sciences, Faculty of Mathematics and Natural Sciences, Universitas Sriwijaya, Palembang, South Sumatra, Indonesia.

Received: October 28, 2025

Revised: November 21, 2025

Accepted: November 28, 2025

Published: December, 31 2025

Corresponding Author:

Ida Sriyanti

ida_sriyanti@unsri.ac.id

DOI: [10.29303/ujcs.v6i4.1269](https://doi.org/10.29303/ujcs.v6i4.1269)

© 2025 The Authors. This open access article is distributed under a (CC-BY License)



Abstract: Educational transformation in the Industrial Revolution 4.0 era demands that teachers adapt to digital technology and develop innovation-based learning. However, the results of a preliminary survey indicated that a majority of teachers at SMAN 10 Palembang lacked skills in creating digital learning media and were unfamiliar with Augmented Reality (AR) technology. This community service activity aimed to improve teacher competence through mentoring in the creation of AR-based interactive e-modules as a 21st-century learning innovation. The implementation methods included socialization, technical training, a coaching clinic, and an evaluation of outcomes using a pre-test, post-test, and a participant satisfaction survey. Fifteen teachers actively participated in this activity. The paired sample t-test analysis revealed a significant increase between the pre-test ($M = 47.00$; $SD = 7.75$) and post-test scores ($M = 91.67$; $SD = 4.87$), with $t = -18.506$, $p = 0.000$ ($p < 0.05$). And the Cohen's $d = 9.35$, categorized as a very large effect. This finding demonstrates that the mentoring program was effective in enhancing teacher competence in developing AR-based interactive e-modules. Furthermore, the results of the participant satisfaction survey reinforced the program's effectiveness. A total of 73.3% of participants stated they were "very satisfied" with the quality of the mentoring and facilitators, while 80% felt their e-module creation skills had significantly increased. Regarding the AR integration aspect, 87% of participants expressed high satisfaction with the clarity of the training and the implementation results. Meanwhile, 67% rated the activity as having a direct impact on enhancing their instructional technology integration skills. All participants demonstrated a high commitment to sustainably implementing the training outcomes in their respective schools. Consequently, this program is proven to have a positive impact on enhancing digital literacy, pedagogical competence, and teacher readiness to face the challenges of 21st-century, technology-based learning.

Keywords: Creativity, Content, School, Technology, Workshop.

Introduction

The rapid development of digital technology in the Industrial Revolution 4.0 era has significantly

transformed the educational paradigm. Education is no longer solely focused on knowledge transfer but also on the development of 21st-century competencies: critical thinking, creativity, communication, and collaboration

How to Cite:

Sriyanti, I., Marlina, L., Mataram, A., Sanjaya, M. R., Syahputri, S. M., Dani, R., & Almafie, M. R. (2025). The Enhancement of Teacher Competency Through Assistance in Creating Augmented Reality-Based Interactive E-Modules at SMAN 10 Palembang. *Unram Journal of Community Service*, 6(4), 824–835. <https://doi.org/10.29303/ujcs.v6i4.1269>

(4C). In this context, teachers, as the primary agents of learning transformation, are required to innovate and integrate technology into the teaching and learning process to make learning more contextual, interactive, and student-centered.

One form of innovation relevant to these demands is the use of interactive e-modules combined with Augmented Reality (AR) technology as a learning medium (Febriningrum & Purwaningsih, 2022; Putri et al., 2025). Augmented Reality is a technology that integrates the real world and virtual objects in real-time using digital devices such as smartphones or tablets. In the context of science education, AR can render abstract phenomena or concepts into three-dimensional visualizations that are easily understood by students (Febriningrum & Purwaningsih, 2022; Putri et al., 2024). Studies show that the integration of AR in learning can significantly improve conceptual understanding and students' critical thinking skills (Febriningrum & Purwaningsih, 2022; Putri et al., 2024). Therefore, the application of AR in interactive e-modules is deemed highly promising for creating 21st-century learning that is technology-based, visual, and participatory.

However, in practice, not all teachers possess the skills and experience to develop AR-based digital learning media. One area facing this challenge is Bukit Besar District in Palembang City, South Sumatra Province. This region is a strategic area in the western part of Palembang City, undergoing rapid development in terms of education and infrastructure (Krisnamutri, 2018). Despite this, digital literacy among teachers, particularly science teachers, remains relatively low. Based on a preliminary survey conducted by the Sriwijaya University community service team, it was found that 76% of teachers had never used digital e-modules, and 80% were unfamiliar with AR applications such as Assemblr Edu. Furthermore, 88% of teachers had never been involved in technology-based, best-practice-sharing forums, indicating a weak collaborative culture within the school environment. As part of a targeted development area (*kawasan binaan*) for Sriwijaya University (UNSRI), Ilir Barat I District has become a focus for teacher capacity building and technology-based educational innovation. The primary partner in this activity is SMAN 10 Palembang, an 'A'-accredited public high school. The school possesses adequate supporting facilities, including computer laboratories, a 20 Mbps internet network, and teachers' personal digital devices. Its strategic location at Jln. Sriwijaya Negara No.195, Bukit Lama, Ilir Barat I District, Palembang City, South Sumatra 30138, is approximately 3 km from the UNSRI Palembang Campus, with a travel time of ± 3 minutes, making it highly representative as a central location for the service program's implementation.

Despite possessing great potential, the existing conditions indicate a gap between the available infrastructure and the teachers' digital skills. The challenges faced by the partner encompass three main aspects: (1) limited skills in developing AR-based learning media, (2) the absence of an established collaborative culture among teachers, and (3) the suboptimal utilization of school facilities for digital learning. These barriers have resulted in science instruction remaining dominated by conventional methods, which lack visual and interactive innovation. To address these problems, the UNSRI service team designed a "Mentoring Program for Creating Interactive E-Modules Combined with Augmented Reality as a 21st-Century Learning Innovation for Science Teachers in Ilir Barat I District." This activity aims to enhance the competence of science teachers in developing and implementing innovative, technology-based learning media. The program combines two main tools: Canva, for designing attractive and user-friendly interactive e-module interfaces, and Assemblr Edu, for adding AR elements such as three-dimensional objects, animations, and science simulations. The integration of these two enables teachers to create e-modules that are not only informative but also interactive and contextual, in accordance with the characteristics of 21st-century learners (Garris Pelangi, 2020; Putri et al., 2024).

This mentoring program is implemented through systematic stages, including socialization, technical training, intensive assistance (coaching clinic), the formation of an innovative teacher community, and the dissemination of results via a demo day. During the training, science teachers will learn to develop e-module storyboards based on the Merdeka Curriculum, integrate AR elements, and conduct live trials in classroom instruction. The mentoring phase is conducted on an ongoing basis to ensure teachers can apply the acquired skills independently and consistently. Meanwhile, the formation of the innovative teacher community serves as a collaborative platform for sharing best practices and extending the program's impact to other schools in the surrounding region (Final Proposal Pengabdian UNSRI, 2025). From a sustainable development perspective, this activity is aligned with Sustainable Development Goal (SDG) 4, namely Quality Education, which emphasizes the improvement of educational quality through strengthening educator capacity. Furthermore, this program supports the achievement of the Higher Education Key Performance Indicators (IKU), specifically IKU 5 (Faculty work output utilized by the community) and IKU 7 (Collaborative and participatory classes). At the institutional level, this activity also contributes to Sriwijaya University's flagship program, namely Outcome-Based Learning and Teaching Innovation

(Final Proposal Pengabdian UNSRI, 2025). Previous studies indicate that the use of AR in learning not only enhances conceptual understanding but also fosters interest in learning and active student participation. Marlina et al. (2024) reported a 23% increase in science learning outcomes for students learning via AR-based media compared to those using conventional methods (Putri et al., 2024, 2025). Moreover, teachers involved in AR training demonstrated improved digital literacy and enhanced pedagogical competence. Therefore, through this mentoring program, it is hoped that the science teachers at SMAN 10 Palembang, Ilir Barat I District, will be transformed into educators who are creative, collaborative, and adaptive to changes in educational technology.

Method

Place and Time

This community service program was implemented over a six-month period, beginning September 15 and concluding on October 30, 2025. The entire series of activities took place at SMAN 10 Palembang, located at Jln. Sriwijaya Negara No.195, Bukit Lama, Ilir Barat I District, Palembang City, South Sumatra 30138. This school was selected as the primary partner because it possesses adequate ICT facilities and a strong commitment to the development of science learning innovations. The activities were conducted in-person, adjusted to the teachers' schedules and the availability of the school's computer laboratory. These activities included socialization, training, and coaching clinic sessions. Meanwhile, online activities were utilized for follow-up mentoring, teacher community discussions, and monitoring of participant outcomes.

Participants

This community service activity was implemented with the primary target audience being teachers at SMAN 10 Palembang. The number of participants involved in this activity was 15 teachers, who actively participated in the entire series of training and mentoring.

Tools and Materials

The tools and materials used in this activity included computers and laptops for the e-module design process, Android or iOS-based smartphones for displaying Augmented Reality (AR) content, and the school's 20 Mbps internet network, which supported optimal digital content access. Additionally, an LCD projector, camera, and tripod were used to support the training activities and for results documentation. The primary software utilized consisted of Canva and Google Sites for the creation and publication of

interactive e-modules, as well as Assemblr Edu and Zappar for Augmented Reality element integration. All of this software is open-access, as it is available through the akun belajar.id (learning accounts) facilitated by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. This enables teachers to access and operate the applications independently at no additional cost, while also ensuring the sustainable use of this technology after the community service program concludes.

Orientation for the School Partner

The implementation methodology for this community service program was systematically designed to address the needs of the partners: the science teachers at SMAN 10 Palembang, Ilir Barat I District, who are still facing challenges in their proficiency with digital-based learning technology and Augmented Reality (AR). The program was conducted through a participatory approach and hands-on practice, emphasizing collaboration between the service team and the school partner. This orientation for the school partner was conducted to establish a common understanding between the service team and the school regarding the program's objectives, benefits, and implementation stages. The orientation was held via an in-person meeting involving the principal, science teachers, and representatives from the Sriwijaya University service team. In this phase, the team explained the urgency of digital literacy proficiency for teachers in the 21st-century learning era and introduced the fundamental concepts of AR-based interactive e-modules. Furthermore, a preliminary assessment of the teachers' abilities in using digital media and an identification of training needs were conducted. The outcome of this stage was an agreement on the activity schedule, participant commitment, and the full support of the school for the program's implementation.

Training Workshop and Mentoring on E-Module and AR Development

The training and workshop on the development of Augmented Reality (AR)-based e-modules constituted the core of the teacher capacity-building process. During this stage, a preliminary survey instrument (pre-test) was also administered to measure the teachers' digital literacy levels and their initial understanding of using E-Module and AR-based media. The training began with an introduction to the foundational theory of interactive e-modules, principles of digital instructional design, and the potential of AR technology to visualize abstract science concepts. Following the theory session, teachers were given the opportunity to engage in hands-on practice using easily accessible applications such as Assemblr Edu. Through technical guidance, teachers

learned to create storyboards, design learning content, and integrate 3D elements into the digital e-modules they developed using Canva. Each participant was required to produce at least one AR-based e-module prototype relevant to their subject area. The workshop methodology was collaborative and project-based, allowing teachers to learn from direct experience and engage in peer-to-peer discussions. Mentoring, or the coaching clinic, was conducted post-training; teachers received intensive guidance, both individually and in small groups, to refine the e-modules they had created. This coaching clinic was held periodically, focusing on troubleshooting technical constraints, content refinement, and the implementation of the e-modules in the classroom learning process. The mentoring also included guidance on basic digital literacy, such as time management, publishing their work, and developing independent study guides. The service team conducted observations and provided direct feedback on the teachers' products.

Data Collection and Analysis Techniques

Data collection techniques in this community service program were conducted through tests and questionnaires to measure the increase in participants' competence and their satisfaction level with the implemented activities. This program involved 15 participants, consisting of teachers from various schools. Teacher competence was measured using pre-test and post-test instruments, each comprising 20 items related to the conceptual understanding of interactive e-modules and the application of Augmented Reality (AR) technology in learning. The initial test (pre-test) was administered before the training activity to determine the participants' initial abilities, while the final test (post-test) was administered after the entire series of activities was completed to measure the competency gains. Additionally, a user satisfaction evaluation was conducted through the distribution of closed-ended and open-ended questionnaires to the participants. The questionnaire covered aspects such as the suitability of training materials, the clarity of the instructor's delivery, the ease of application use, the activity's benefits to teaching practices, and the participants' motivation level to apply AR technology in the classroom. The collected data was analyzed quantitatively and qualitatively using descriptive methods, by calculating the increase in mean scores from the pre-test and post-test, as well as interpreting participant responses to the program's implementation. The results of this analysis were used to assess the program's effectiveness and provide feedback for the development of similar mentoring programs in the future. Subsequently, a paired-samples t -test, using SPSS Version 27 (IBM Statistics), was employed to statistically test the program's

effectiveness. This was done by examining the t -value, p -value, and effect size to determine the significance of the increase in teacher competence following the training.

Result and Discussion

Program Introduction and Initial Coordination with the School Partner

The orientation phase is a strategic initial step in determining the direction and success of the entire mentoring program for creating interactive e-modules based on Augmented Reality (AR). This activity focused on establishing a common understanding between the service team from Sriwijaya University and the partners—in this case, the principal and science teachers at SMAN 10 Palembang, Bukit Siguntang, Palembang. Figure 1. Documentation of the orientation activity for the school partner, including the display of the community service poster, a group photo with the principal and teachers, and the delivery of a brief orientation to the teachers. Through this activity, the team sought to instill a deep understanding of the urgency of mastering digital learning technology and to build initial commitment to the program's implementation. The orientation was conducted through an in-person meeting attended by the principal, the vice-principal for curriculum, and science teacher representatives as the program's primary participants. During this opportunity, the service team leader presented the program's background, which stemmed from the teachers' low digital literacy and the minimal utilization of technology-based learning media at the school. Low digital literacy has been shown to be one of the inhibiting factors for the implementation of innovative ICT-based learning in schools (Wiyono et al., 2024). This explanation served as the foundation for the argument that mentoring in the development of AR-based interactive e-modules is highly relevant to teachers' needs in facing 21st-century learning challenges, which demand creativity, collaboration, communication, and critical thinking skills (Wiyono et al., 2024).



Figure 1. Documentation of the orientation activity for the school partner, including the display of the community service poster, a group photo with the principal and teachers, and the delivery of a brief orientation to the teachers.

This explanation served as the foundation for the argument that mentoring in the development of AR-based interactive e-modules is highly relevant to teachers' needs in facing 21st-century learning challenges, which demand creativity, collaboration, and critical thinking skills. In addition to the conceptual presentation, the orientation also served as a forum for two-way communication between the implementation team and the school (Nadia et al., 2024; Utami et al., 2024). The teachers were given the opportunity to express their constraints and expectations regarding the program's implementation. The majority of teachers revealed that although technological facilities such as computers and an internet network were available, their utilization in learning was still limited due to a lack of practical training focused on technology integration into science materials. This response indicated that the community service program to be implemented genuinely addresses the needs on the ground. In the same forum, the principal affirmed their full support for this activity and assigned the science teachers to participate actively throughout the program's duration. This support included the provision of school facilities and infrastructure, scheduling activities in alignment with the academic calendar, and the appointment of a teacher coordinator to act as a liaison between the school and the service team. This decision strengthened the activity's legitimacy while simultaneously demonstrating the institution's commitment to realizing technology-based learning transformation (Anjarwati et al., 2025).

Workshop on Augmented Reality-Based Interactive E-Module Development



Figure 2. Documentation of the first day's activities of the training and workshop at SMAN 10 Palembang, including the opening remarks by the Team Leader, the Principal's welcome speech, the presentation of materials by the team of lecturers and students, and an interactive question-and-answer session.

The training and workshop phase constituted the core of the community service program, focusing on enhancing teacher competence in designing interactive and contextual digital learning media. This competency development activity is aligned with the demands of the Education 4.0 era, where teachers are expected to utilize digital technology to support creative and collaborative learning processes (Anjarwati et al., 2025; Sutriyono et al., 2022). The activity was conducted in-person at SMAN 10 Palembang over two days, involving a team of lecturers and students from Sriwijaya University as resource persons and facilitators. Figure 2 shows the documentation of the first day's activities of the training and workshop at SMAN 10 Palembang, which included the opening remarks by the Team Leader, the welcome speech from the Principal, the presentation of materials by the team of lecturers and students, and an interactive question-and-answer session. This workshop-based training model is based on the experiential learning approach, where participants gain direct experience through practice and reflection on the activities performed (Astra Patriot et al., 2023; Muin et al., 2025). This training was designed for teachers to gain both theoretical understanding and practical experience in creating interactive Augmented Reality (AR)-based e-modules using Canva and Assemblr Edu. The utilization of AR in learning has been proven to enhance abstract conceptual understanding, student engagement, and learning motivation by providing visual and interactive experiences (Febriningrum & Purwaningsih, 2022; Ramadhan et al., 2023). The first day's implementation began with the official opening by the Service Team Leader, who emphasized the importance of this activity as part of Sriwijaya University's commitment to supporting 21st-century learning transformation. In their address, they highlighted that teachers not only

need to understand science content but also be able to present it in an engaging manner with the help of digital technology.



Figure 3. Documentation of the Second Day's activities of the training and workshop at SMAN 10 Palembang, covering the hands-on practice of creating e-modules and AR content, direct mentoring by the student team, presentation of preliminary results, and the closing of the activity by the Team Leader and the Vice-Principal for Public Relations.

The event then continued with a welcome speech from the Principal of SMAN 10 Palembang, who expressed appreciation and full support for the implementation of the activity. The principal affirmed that the training outcomes were expected to be applied in teaching and learning activities and to become a sustainable innovation. After the opening, participants completed the pre-test to measure their initial level of understanding regarding e-module and AR concepts. Subsequently, the team of lecturers delivered an introductory presentation on digital e-module development using Canva, which emphasized instructional design principles such as visual consistency, information balance, and media integration (Ramadhan et al., 2023). In the following session, the student team demonstrated the use of the Assemblr Edu application to create three-dimensional content that could be linked to the module via QR code. This integration of 3D elements helped participants understand that spatial visualization is crucial in science learning (Febriningrum & Purwaningsih, 2022). Participants were shown examples of AR-based science media capable of visualizing abstract concepts such as the solar system and molecular structures. The first day's session was dynamic. The teachers were enthusiastic about trying the introduced applications, asking questions, and discussing the potential application of AR in the classroom. The active participation of the participants in the hands-on session demonstrated the effectiveness of the hands-on approach in enhancing self-confidence and technological readiness (Astra Patriot et al., 2023; Fathurohman et al., 2023). This interaction fostered participants' confidence in exploring new technologies that were previously considered complicated.

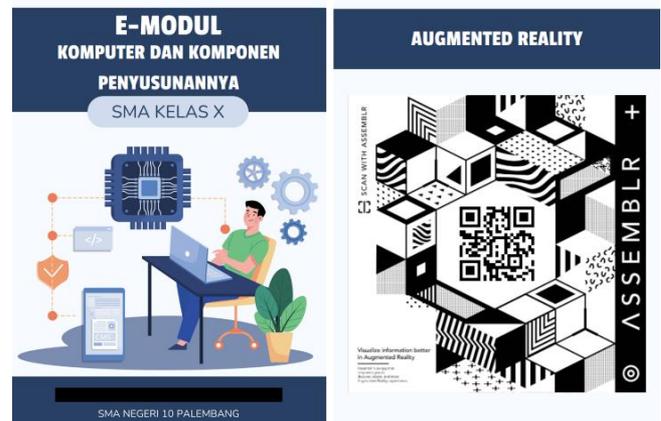


Figure 4. E-Modules produced by the mentoring participants, showcasing the teachers' work after participating in the training activity.

The second day focused on independent practice and the creation of Augmented Reality (AR)-based e-modules, which represent a form of 21st-century digital learning innovation. Figure 3 shows the documentation of the Second Day's activities of the training and workshop at SMAN 10 Palembang, covering the hands-on practice of creating e-modules and AR content, direct mentoring by the student team, presentation of preliminary results, and the closing of the activity by the Team Leader and the Vice-Principal for Public Relations. The use of AR in education has been proven to enhance student engagement, conceptual understanding, and learning motivation (Febriningrum & Purwaningsih, 2022; Putri et al., 2024). Each teacher developed an e-module draft according to the subject they teach, with intensive guidance from the student team. They learned to apply multimedia-based digital instructional design principles, including creating storyboards, laying out pages, inserting video links, and adding QR codes linked to 3D objects from Assemblr Edu, which is known to be effective as an interactive AR-based learning platform (Febriningrum & Purwaningsih, 2022). The participants' work is shown in Figure 4. After the practice session, a presentation of preliminary results was held to provide mutual feedback. The service team provided evaluations based on pedagogical aspects, design aesthetics, media integration, and alignment with learning objectives. This formative evaluation process is important in the e-module development cycle to ensure the resulting products meet effectiveness and usability criteria. The atmosphere on the second day of training showed an increase in participants' skills and enthusiasm. This aligns with the Technological Pedagogical Content Knowledge (TPACK) theory, which emphasizes the importance of integration between technology, pedagogy, and content knowledge in the development of learning media.

Several teachers were able to showcase initial interactive e-module prototypes featuring illustrations, experiment videos, and 3D visualizations they had created themselves. The activity concluded with a joint reflection and closing remarks from the Team Leader and the Vice-Principal for Public Relations. The Team Leader emphasized that the training outcomes should be immediately implemented in teaching and learning, while school representatives stated that the teachers' work would be incorporated into the school's performance evaluation for learning innovation. This step reflects the school-based professional development approach, which emphasizes continuous learning for teachers within their own work environment (Komarudin et al., 2025; Sari & Wiyono, 2025). In addition to the in-person activities, the team also established a supporting online forum via a WhatsApp Group to share additional materials, tutorials, and a space for further discussion. The use of an online platform as a follow-up to the training supports the principle of blended learning, which is flexible and collaborative (Chairatunnisa et al., 2023; Nazhifah et al., 2023). This measure ensured that participants could continue to interact and proceed with product development outside of the training sessions. This training and workshop had a tangible impact on enhancing teacher digital literacy. From initially being unaccustomed to using design and AR applications, the teachers are now capable of producing e-module prototypes relevant to their teaching materials. This reinforces the finding that hands-on, practice-based training can enhance self-confidence, creativity, and teachers' innovative capabilities in utilizing educational technology (Koehler et al., 2013).

Program Evaluation

Based on the results of the descriptive analysis, as shown in Table 1 (Paired Samples Statistics), there was a significant increase between the mean pre-test and post-test scores of the mentoring program participants. The mean score before the treatment (pre-test) was 47.00, whereas after the activity (post-test), it increased to 91.67, representing an increase of 44.67 points. This increase indicates that the mentoring program on creating Augmented Reality (AR)-based interactive e-modules had a positive impact on enhancing teacher competence. Interactive e-modules can improve learning effectiveness through the presentation of content that is engaging, interactive, and digitally accessible. Furthermore, the use of AR in learning has also been proven to enhance abstract conceptual understanding and learner engagement (Anjarwati et al., 2025; Fitonia et al., 2024). The standard deviation value decreased from 7.75 to 4.87 after the activity, which means the variation in results among participants became smaller, and their understanding became more

homogeneous. This finding indicates that the training program successfully imparted uniform knowledge and skills related to the creation of AR-based interactive e-modules (Nadia et al., 2024; Utami et al., 2024).

Table 1. Paired Samples Statistics

Treatment	Mean	N	Std. Deviation	Std. Error Mean
Before being given treatment	47.0000	15	7.746	2.000
Afer being given treatment	91.6667	15	4.879	1.259

Table 2. Paired Samples Correlations

Treatment	N	Correlation	Sig.
Before being given treatment & Afer being given treatment	15	-0.047	0.867

The correlation between the pre-test and post-test scores, as shown in Table 2 (Paired Samples Correlations), was $r = -0.047$ with a significance of $p = 0.867$. This indicates a weak and non-significant relationship, suggesting that the difference in scores is attributed to the influence of the mentoring program rather than random chance. The results of the paired-samples t-test in Table 3 (Paired Samples Test) show a $t = -18.506$ with a significance of $p = 0.000$ ($p < 0.05$), which means there is a highly significant difference between the pre-test and post-test results. Thus, the mentoring program is proven effective in enhancing teachers' ability to develop digital technology-based learning innovations. The effect size measurement in Table 4 (Paired Samples Effect Sizes) reveals a Cohen's $d = 9.35$ and Hedges' correction = 9.61, which falls into the 'very large effect' category (Cohen, 1988). This value indicates that the program's impact on improving teacher competence is very strong and practically significant. Theoretically, the combination of text, images, and interactive elements like AR can strengthen the learners' information comprehension and retention processes (Putri et al., 2025; Wiyono et al., 2024).

Table 3. Paired Samples Test

Treatment	Paired Differences				t	df	Sig. (2-tailed)	
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower				Upper
Before being given treatment - After being given treatment	-44.667	9.348	2.414	-49.84329	-39.490	-18.506	14	0.000

Table 4. Paired Samples Effect Sizes

Treatment	Effect Sizes	Standardizer ^a	Point Estimate	95% Confidence Interval	
				Lower	Upper
Before being given treatment -	Cohen's d	9.34778	-4.778	6.593	-2.951
Afer being given treatment	Hedges' correction	9.60784	-4.649	6.414	-2.871

^aThe denominator used in estimating the effect sizes. Cohen's d uses the sample standard deviation of the mean difference. Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Overall, these findings affirm that a systematically designed mentoring program, utilizing a hands-on approach and cutting-edge technology like Augmented Reality, can have a significant impact on enhancing digital literacy and 21st-century learning innovation for teachers. The substantial increase in post-test results indicates that participants not only understood the theoretical concepts of e-module creation but were also able to integrate AR technology within an interactive and engaging learning context for students. Thus, this activity can be deemed highly effective in improving the pedagogical and technological competence of teachers at SMAN 10 Palembang. This success can serve as a model for other schools in developing teacher capacity-building programs that are relevant to the needs of modern digital education and aligned with the demands of 21st-century learning.

Participant Survey for the Community Service Program

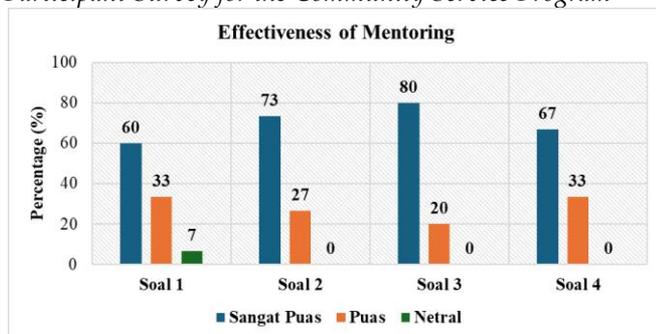


Figure 5. Participant satisfaction level on the Mentoring and Facilitator Aspect, comprising four statement items (Items 1-4).

The aspect of mentoring effectiveness was measured through four statement items assessing the extent of the mentoring approach, facilitator capabilities, and the activity's benefits in enhancing participant

capacity. The survey results indicated that the majority of participants provided very positive ratings for the mentoring implementation, as shown in Figure 5. For Item 1, which assessed the effectiveness of the mentoring approach in helping participants understand the E-Module creation stages and AR integration, 9 people (60%) stated "very satisfied," 5 people (33.3%) were "satisfied," and 1 person (6.7%) was neutral. Item 2, which assessed the facilitators' ability to adapt mentoring methods to the participants' digital skills and needs, received even higher results, with 11 people (73.3%) stating "very satisfied" and 4 people (26.7%) "satisfied." Furthermore, Item 3, which assessed the benefit of the mentoring on enhancing participant capacity as educators or digital learning practitioners, showed the highest results, with 12 people (80%) "very satisfied" and 3 people (20%) "satisfied." As for Item 4, which measured the participants' level of understanding of instructional design principles and interactivity after the activity, it also showed excellent results, with 10 people (66.7%) "very satisfied" and 5 people (33.3%) "satisfied." No participants expressed "dissatisfied" or "very dissatisfied" on any of these statement items. These results indicate that the mentoring activity was highly effective in helping participants understand and master the creation process for AR-based interactive E-Modules. The facilitators were deemed capable of adapting the mentoring methods to the participants' digital skill levels, providing relevant explanations and examples, and creating a collaborative and easy-to-understand learning atmosphere, thereby having a positive impact on the enhancement of participant competence.

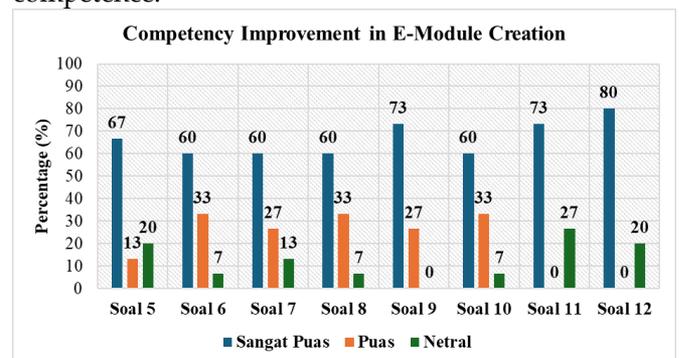


Figure 6. Participant satisfaction level on the "Competency Improvement in E-Module Creation" aspect, comprising twelve statement items (Items 5-12).

The E-Module development aspect comprised eight statement items (Items 5-12) that assessed the quality of the guidance process, participants' understanding of instructional design principles, multimedia application, technical skills, and the final interactive E-Module product, as shown in Figure 6. The survey results indicate that the majority of participants

gave a "Very Satisfied" rating, signifying that the mentoring activity was highly effective and well-executed. For Item 5, which assessed the quality of guidance in structuring the E-Module (objectives, materials, evaluation, and navigation), 67% of participants stated "very satisfied," 13% "satisfied," and 20% "neutral." Item 6, regarding the clarity of explanations and examples of multimedia integration (text, audio, video, and animation) into the E-Module, received 60% "very satisfied," 33% "satisfied," and 7% "neutral." Furthermore, Item 7, which assessed participants' ability to apply technical skills such as using authoring software, layout, hyperlinks, and interactive elements, showed results of 60% "very satisfied," 27% "satisfied," and 13% "neutral." For Item 8, which assessed the relevance and contextuality of the E-Module product to student needs, the results were 60% "very satisfied," 33% "satisfied," and 7% "neutral." Item 9, which assessed the extent to which the E-Module could enhance student motivation and engagement, showed 73% "very satisfied" and 27% "satisfied," with no neutral or negative responses. Item 10, which measured the mentoring's contribution to participants' ability to manage and publish the E-Module independently, also showed positive results with 60% "very satisfied," 33% "satisfied," and 7% "neutral." Meanwhile, Item 11, which assessed the pedagogical and technical quality of the produced interactive E-Module, showed 73% of participants were "very satisfied," 27% "neutral," and none felt "dissatisfied." Finally, Item 12, which assessed participants' understanding of design principles and interactivity post-mentoring, received the highest results: 80% "very satisfied," 20% "neutral," and no one stated "dissatisfied." Thus, these data indicate that the mentoring activity had a very significant impact on enhancing participants' competence in designing interactive E-Modules. Participants not only understood the structure and principles of instructional design but were also able to apply various multimedia elements and integrate interactivity aspects into their products.

The Augmented Reality (AR) integration aspect comprised eight statement items (Items 13–20) that assessed participants' understanding of AR pedagogical concepts, the clarity of the technical training, the ability to overcome implementation constraints, and the readiness to apply and disseminate the mentoring outcomes, as shown in Figure 7. Overall, the survey results indicated that the majority of participants gave a "Very Satisfied" rating, which signifies that the mentoring activity successfully provided a learning experience that was effective, applicative, and relevant to the needs of AR-based learning media development. For Item 13, which assessed participants' understanding of the pedagogical concept of using AR to reinforce concept visualization and learning experiences, 67% of participants stated "very satisfied," 27% "satisfied," and 7% "neutral." Item 14, regarding the effectiveness of the training in explaining the mechanisms for creating, configuring, and linking AR objects into the E-Module, showed high results with 80% "very satisfied" and 20% "neutral." Item 15, which assessed the extent to which the mentoring helped participants overcome technical difficulties in the AR implementation process, revealed 73% "very satisfied," 20% "satisfied," and 7% "neutral." Meanwhile, Item 16, which assessed the extent to which AR added interactivity value and learning appeal compared to conventional E-Modules, showed similar results with 80% "very satisfied" and 20% "neutral." Furthermore, Item 17, which assessed participants' ability to select appropriate materials to be visualized with AR, showed 73% "very satisfied," 7% "satisfied," and 20% "neutral." Item 18, regarding the quality of AR integration in terms of functional, aesthetic, and pedagogical aspects, received the highest results with 87% "very satisfied," 7% "satisfied," and 7% "neutral." For Item 19, which assessed the activity's impact on enhancing participant competence in designing innovation-based digital learning media, the results were 73% "very satisfied," 7% "satisfied," and 20% "neutral." Finally, Item 20, which measured participants' commitment and readiness to continue or disseminate the practice of creating AR-based interactive E-Modules, showed the same results, namely 73% "very satisfied," 7% "satisfied," and 20% "neutral." Overall, these results demonstrate that participants have a very high level of satisfaction with the AR integration aspect. Thus, participants were able to understand the pedagogical and technical concepts of AR usage and could implement them effectively within the digital learning context. Furthermore, participants demonstrated strong motivation to develop and implement this innovation sustainably in their respective work environments.

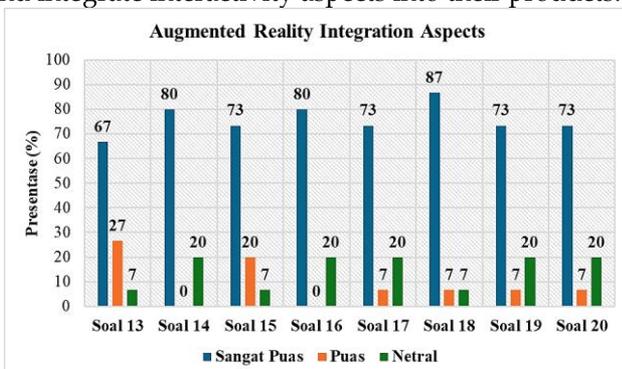


Figure 7. Participant satisfaction level on the Augmented Reality Integration Aspect, comprising twelve statement items (Items 13-20).

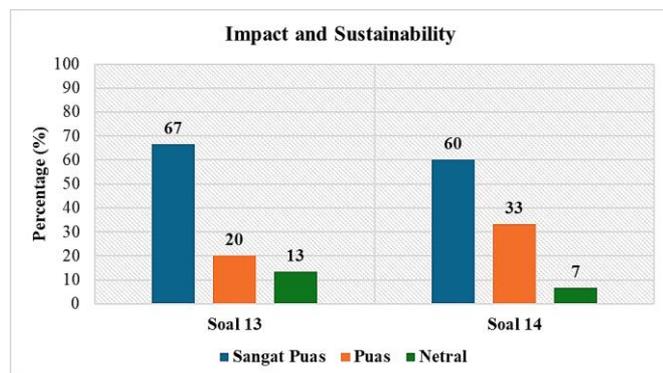


Figure 8. Participant satisfaction level on the Impact and Sustainability Aspect, comprising twelve statement items (Items 13-14).

The "Impact and Sustainability" aspect focuses on the extent to which the mentoring activity influences the enhancement of participant competence and fosters their commitment to sustainably implement the training outcomes, as shown in Figure 8. Based on the questionnaire results for Items 21 and 22, it is evident that the majority of participants gave very positive ratings for this aspect. For Item 21, which assessed the activity's impact on enhancing teachers' ability to integrate innovative learning technologies based on e-modules and Augmented Reality (AR), 67% of participants stated "very satisfied," 20% "satisfied," and 13% "neutral." This result indicates that the mentoring activity has made a significant contribution to enhancing participant understanding and skills, in terms of both technical and pedagogical aspects. Participants felt this activity helped them understand how technology can be effectively utilized to improve the quality of 21st-century learning. Meanwhile, Item 22 assessed participants' commitment to applying and developing the training outcomes sustainably in their respective schools. 60% of participants stated "very satisfied," 33% "satisfied," and only 7% "neutral." This result indicates that the majority of participants have a high level of enthusiasm to implement AR-based interactive e-modules and to share this knowledge with their peers in their work environment. The absence of "dissatisfied" or "very dissatisfied" responses indicates that this activity was perceived as highly relevant, beneficial, and having a tangible impact on the participants. Thus, the "Impact and Sustainability" aspect can be concluded as highly successful in fostering adaptive capacity, innovative motivation, and teachers' collaborative spirit to continuously develop technology-based learning independently and sustainably.

Conclusion

The mentoring program on Creating Interactive E-Modules Combined with Augmented Reality (AR) for

teachers at SMAN 10 Palembang was proven effective in enhancing participant pedagogical competence and digital literacy. Based on the pre-test and post-test results, a significant increase occurred from a mean score of 47.00 to 91.67, with $t = -18.506$ ($p = 0.000$) and a very large effect size (Cohen's $d = 9.35$). This finding indicates that the mentoring program had a strong influence on improving teachers' ability to develop and implement digital technology-based learning media. In addition to the competency enhancement, the satisfaction survey results showed that all participants gave ratings from "satisfied" to "very satisfied" on all aspects of the activity, including mentoring effectiveness, facilitator quality, mastery of e-module creation skills, and AR technology integration in learning. Teachers felt this activity was relevant to 21st-century learning needs because it helped them develop media that is interactive, contextual, and engaging for learners. The program successfully enhanced the adaptive capacity, creativity, and collaboration of teachers in integrating technology into the learning process. This activity can serve as a model for sustainable, technology-based teacher professional development, and it supports the achievement of Sustainable Development Goal 4 (Quality Education) and the Higher Education Key Performance Indicators (IKU), particularly in the field of digital learning innovation.

Acknowledgments

The community service/publication of this article was funded Universitas Sriwijaya 2025. In accordance with the Rector's Decree Number: 0014/UN9/SK.LPPM.PM/2025, on September 17, 2025.

Author Contributions

Ida Sriyanti: Conceptualization, Methodology, Investigation, Supervision, Project administration, Funding acquisition, Writing - review & editing. Leni Marlina: Supervision, Investigation. Agung Mataram: Supervision, Investigation. Muhammad Rudi Sanjaya: Formal analysis, Software. Selvia Mariska Syahputri: Investigation, Software. Rahma Dani: Methodology, Resources, Writing - review & editing, Visualization. Muhammad Rama Almafie: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision.

Conflicts of Interest

The authors declare that they have no financial conflicts of interest or personal relationships that could influence the work reported in this paper.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

The authors affirm that no AI-based tools were used in the production of this study.

References

- Anjarwati, N., Wiyono, K., & Sriyanti, I. (2025). Implementation of E-Module Containing Local Wisdom Based on the Theory of Conceptual Change to Improve Understanding High School Students' Concepts on Work and Energy Materials. *Jurnal Penelitian Pendidikan IPA*, 11(4), 187-194. <https://doi.org/10.29303/jppipa.v11i4.8668>
- Astra Patriot, E., Wiyono, K., Sriyanti, I., Nazhifah, N., Fitonia, A., Nadia, H., Utami, Y., Rokhati Harianja, M., Fadhilah, S., Meitasari, D., & Arrum Sari, N. (2023). Enchancing The Skills of Physics MGMP Teachers in making differentiated E-Modules. *Transformasi: Jurnal Pengabdian Masyarakat*, 19(2), 272-282. <https://doi.org/10.20414/transformasi.v19i2.8441>
- Chairatunnisa, A., Marlina, L., & Wiyono, K. (2023). Improvement of Critical Thinking Skills of Junior High School Students on Heat Transfer Material. *Jurnal Penelitian Pendidikan IPA*, 9(11), 10377-10386. <https://doi.org/10.29303/jppipa.v9i11.5681>
- Fathurohman, A., Oklilas, A. F., Marlina, L., Kurdiati, L. A., Susiloningsih, E., Azhar, A., & Samsuryadi, S. (2023). Effectiveness of Using the Mobile Learning App for STEM-Based High School Physics Materials as Indonesian Student Learning Resources on Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(3), 1018-1023. <https://doi.org/10.29303/jppipa.v9i3.2991>
- Febriningrum, D. P., & Purwaningsih, S. M. (2022). Pengaruh Aplikasi Assemblr Edu Berbasis Teknologi Augmented Reality Terhadap Hasil Belajar Mata Pelajaran Sejarah Indonesia Kelas XI IPS SMAN 8 Surabaya. *Journal Pendidikan Sejarah*, 13(1).
- Fitonia, A., Wiyono, K., & Sriyanti, I. (2024). Kemplang Panggang and Salted Fish as Potential Issues in Physics e-Module: An Effort to Enhance Students' Creative Thinking Skills. *Jurnal Pendidikan MIPA*, 25(1), 453-467. <https://doi.org/10.23960/jpmipa/v25i1.pp453-467>
- Garris Pelangi. (2020). Pemanfaatan Aplikasi Canva Sebagai Media Pembelajaran Bahasa Dan Sastra Indonesia Jenjang SMA/MA. *Jurnal Sasindo Unpam*, 8(2). <https://doi.org/10.32493/SASINDO.V8I2.79-96>
- Komarudin, K., Akhsan, H., & Wiyono, K. (2025). Preliminary Study of E-modul Based on Ethnoscience Lake Ranau to Improve Literacy skills of Students on Renewable Energy Topic. *Jurnal Penelitian Pendidikan IPA*, 11(3), 1183-1193. <https://doi.org/10.29303/jppipa.v11i3.10653>
- Muin, D., Ismet, I., & Marlina, L. (2025). Teachers' and Students' Needs in Scientific Work Skills: Guided Investigation Laboratory Module for Junior High Schools. *Prisma Sains: Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, 13(3), 756-768. <https://doi.org/10.33394/jps.v13i3.16302>
- Nadia, H., Wiyono, K., & Sriyanti, I. (2024). Effectiveness of Using Physics E-Modules Based on Local Wisdom of Palembang City Food to Improve Collaboration Skills for High School Students. *Jurnal Penelitian Pendidikan IPA*, 10(9), 6376-6383. <https://doi.org/10.29303/jppipa.v10i9.8439>
- Nazhifah, N., Wiyono, K., & Ismet, I. (2023). Development of STEM-Based E-Learning on Renewable Energy Topic to Improve the Students Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(11), 9575-9585. <https://doi.org/10.29303/jppipa.v9i11.5206>
- Putri, M., Marlina, L., Sudirman, S., Murniati, M., & Rizki, I. N. (2025). Analysis of Flashcard Needs Based on Augmented Reality on Dynamic Fluid Material to Improve High School Students Critical Thinking Skills. 583-590. https://doi.org/10.2991/978-2-38476-390-0_48
- Putri, M., Rizki, I. N., Marlina, L., Sudirman, & Murniati. (2024). Development of Flashcard Media Based on Augmented Reality on Dynamic Fluid Material to Train Critical Thinking Skills of High School Students. *Jurnal Penelitian Pendidikan IPA*, 10(12), 10269-10277. <https://doi.org/10.29303/jppipa.v10i12.9778>
- Ramadhan, I., Imran, I., Ulfah, M., Prancisca, S., T, A. Y., Linda, L., Febrianti, U. R., & Wahyudi, A. (2023). Pelatihan Peningkatan Keterampilan Belajar Peserta Didik Menggunakan Aplikasi Canva di Sekolah Perbatasan Indonesia-Malaysia. *Jurnal Pengabdian UNDIKMA*, 4(3), 525. <https://doi.org/10.33394/jpu.v4i3.8353>
- Sari, N. A., & Wiyono, K. (2025). Development of STEM-Based Dynamic Fluid Material E-Module in the Framework of the Perjaya Dam for Grade XI High School Students. *Jurnal Penelitian Pendidikan IPA*, 11(5), 979-985. <https://doi.org/10.29303/jppipa.v11i5.6660>
- Sutriyono, S., Ismet, I., & Wiyono, K. (2022). Efektivitas Model Blended Learning berbasis Media Microsoft Teams pada Materi Elastisitas untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa. *Jurnal Ilmiah Pendidikan Fisika*, 6(1), 36. <https://doi.org/10.20527/jipf.v6i1.4451>
- Utami, Y., Wiyono, K., & Syuhendri. (2024). The Effectiveness of E-Modules Based on Local

Wisdom in the City of Palembang to Improve Thinking Skills High School Students' Criticism of Static Fluid Material. *Jurnal Penelitian Pendidikan IPA*, 10(9), 7095-7102. <https://doi.org/10.29303/jppipa.v10i9.8253>

Wiyono, K., Ismet, I., Andriani, N., Fitonia, A., Nadia, H., Meitasari, D., & Nazhifah, N. (2024). Exploration of Physics Concepts in Local Wisdom of South Sumatera as an Effort to Develop Students' 21st-Century Skills. *Jurnal Penelitian Dan Pengembangan Pendidikan Fisika*, 10(1), 61-78. <https://doi.org/doi.org/10.21009/1.10106>