STRENGTHENING TEACHER COMPETENCE TO SUPPORT SDG 4 THROUGH A GROUNDED AI WORKSHOP

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Abstract

Artificial Intelligence (AI) has *considerable potential to support Sustainable Development Goal 4 (SDG 4) by improving educational quality and strengthening teacher competencies. However, many teachers still face challenges related to AI literacy, information verification, and the risk of AI hallucination, while most training programs focus primarily on general-purpose generative AI. This community service program aimed to strengthen teachers' competencies through a grounded AI workshop using Google Notebook, emphasizing responsible AI use and source-based information verification. The program was implemented for teachers at SMA Al-Abidin Bilingual School (ABBS) Surakarta through preparation, workshop implementation, and evaluation stages. Competency improvement was assessed using a pre-test and post-test design covering five domains: Basic AI Literacy, Preparation and Development of Teaching Materials, Knowledge Management and Classroom Implementation, Learning Evaluation and Feedback, and Professional Development. Statistical analysis was conducted using paired-sample Student's t-tests and Wilcoxon signed-rank tests. Although 60 teachers attended the workshop, 39 complete paired responses were available for analysis. The overall competence score increased significantly from 2.774 to 3.931 ($t = -15.882$, $p < 0.001$), with a very large effect size (Cohen's $d = 2.543$). Significant improvements were observed across all competency domains, with the strongest gains found in Professional Development. The grounded AI workshop effectively strengthened teachers' competencies and promoted more responsible, evidence-based AI usage. The program contributes to SDG 4 by supporting teacher professional development and enhancing educational quality through the adoption of trustworthy AI practices.*

Keywords*: community service; grounded AI; teacher competence; SDG 4*

Abstrak

Artificial Intelligence (AI) memiliki potensi besar untuk mendukung *Sustainable Development Goal* 4 (SDG 4) dengan meningkatkan kualitas pendidikan dan memperkuat kompetensi guru. Namun, banyak guru masih menghadapi tantangan terkait literasi AI, verifikasi informasi, dan risiko halusinasi AI, sementara sebagian besar program pelatihan lebih berfokus pada AI generatif untuk tujuan umum. Program pengabdian masyarakat ini bertujuan untuk memperkuat kompetensi guru melalui workshop *grounded AI* menggunakan Google Notebook, dengan penekanan pada penggunaan AI yang bertanggung jawab dan verifikasi informasi berbasis sumber. Program ini dilaksanakan bagi para guru di SMA Al-Abidin Bilingual School (ABBS) Surakarta melalui tahapan persiapan, pelaksanaan workshop, dan evaluasi. Peningkatan kompetensi dinilai menggunakan desain pre-test dan post-test yang mencakup lima ranah: Literasi Dasar AI, Persiapan dan Pengembangan Materi Ajar, Manajemen Pengetahuan dan Implementasi di Kelas, Evaluasi Pembelajaran dan Umpan Balik, serta Pengembangan Profesional. Analisis statistik dilakukan menggunakan *paired-sample t-test* dan *Wilcoxon signed-rank test*. Meskipun 60 guru mengikuti workshop tersebut, terdapat 39 respons berpasangan lengkap yang tersedia untuk dianalisis. Skor kompetensi keseluruhan meningkat secara signifikan dari 2,774 menjadi 3,931 (t = -15,882, $p < 0,001$), dengan ukuran efek yang sangat besar (Cohen's d = 2,543). Peningkatan

signifikan teramati pada semua ranah kompetensi, dengan peningkatan terbesar ditemukan pada aspek Pengembangan Profesional. Workshop *grounded AI* ini terbukti efektif memperkuat kompetensi guru dan mendorong penggunaan AI yang lebih bertanggung jawab serta berbasis bukti. Program ini berkontribusi terhadap SDG 4 dengan mendukung pengembangan profesional guru dan meningkatkan kualitas pendidikan melalui penerapan praktik AI yang tepercaya.

Kata kunci: *pengabdian masyarakat; grounded AI; kompetensi guru; SDG 4*

1. INTRODUCTION

Quality education serves as a fundamental pillar of sustainable development (Miao et al., 2021; Pambudi et al., 2025). Within the framework of the Sustainable Development Goals (SDGs), this objective is addressed through SDG 4, which targets the provision of inclusive, equitable, and quality education, as well as lifelong learning opportunities for all (Saini et al., 2023). UNESCO emphasizes the strategic importance of education as a prerequisite for achieving other development goals; consequently, enhancing the quality of education must be a primary focus for various stakeholders (Miao et al., 2021; Voogt & Roblin, 2012). Alongside the advancement of digital technology, the use of Artificial Intelligence (AI) is increasingly viewed as a tool that can help accelerate the achievement of SDG 4 by improving the quality of learning, educational management, and educator competency development (Syamsuri et al., 2025).

UNESCO states that AI has the potential to help address various educational challenges, support more personalized learning, strengthen teacher capacity, and enhance the efficiency of educational services (Miao et al., 2021). A study indicates that AI has the potential to support 134 SDG targets—including those related to quality education—through capabilities such as prediction, optimization, and data-driven decision-making (Gohr et al., 2025; Vinuesa et al., 2020). Other study similarly explain that AI in education has the potential to create learning experiences that are more personalized, flexible, inclusive, and engaging, while also helping teachers gain a deeper understanding of students' learning processes (Luckin & Holmes, 2016; Zawacki-Richter et al., 2019). Consequently, various international organizations and governments have begun promoting the integration of AI into education systems as part of the transformation of 21st-century education (Binkley et al., 2012; Harsanti et al., 2025; Trilling & Fadel, 2009; Voogt & Roblin, 2012) .

The landscape of global competition is currently highly dynamic and evolving rapidly (Kavak & Rusu, 2025) . Challenges have intensified, giving rise to previously unrecognized threats (Cerutti et al., 2025) while simultaneously creating new opportunities (Wan & Zhao, 2024) . This highly dynamic shift is driven in part by impressive advancements in AI technology (Leon, 2025). UNESCO emphasizes that the use of AI in education must adhere to principles of inclusivity, equity, transparency, and respect for human rights (Husna & Zakiah, 2025; UNESCO, 2022, 2023). Risks frequently discussed in the literature include algorithmic bias, data privacy violations, unequal access to technology, and the irresponsible use of information (Miao et al., 2021). In the context of Generative AI, an additional issue arises: "AI hallucination", which is AI output that appears convincing but lacks support from valid sources (Kurniawan, 2026; UNESCO, 2023). This phenomenon has the potential to foster misinformation, disinformation, and the use of inaccurate references within educational settings (Kurniawan, 2026; UNESCO, 2023).

Research indicates that teacher readiness is a key factor in the successful use of AI to enhance the quality of education (Darko et al., 2026; Moh et al., 2025; Susilowati et al., 2025) . A national survey of Indonesian teachers found that AI usage in pedagogical activities is

steadily increasing, particularly for developing teaching materials and learning media, conducting assessments, and performing other professional tasks (Aisyah et al., 2026; Apoko, 2025; Mulyani et al., 2025; Widhiyanto et al., 2025). However, teachers simultaneously face challenges such as limited training, uneven AI literacy, overly generic AI outputs, and concerns regarding over-reliance on AI. Other studies show that while Indonesian teachers possess relatively strong pedagogical competence, their AI competence remains low in areas such as AI literacy, AI technological knowledge, and AI ethical knowledge (Zhang et al., 2026). Furthermore, teachers have expressed concerns regarding academic integrity, the potential decline of critical thinking skills, and the lack of adequate guidelines for using AI in learning (Kurniawan, 2026; Susilowati et al., 2025).

These findings suggest that enhancing teacher competence in the AI era requires more than just the ability to use AI applications. Teachers need the skills to evaluate the quality of AI outputs, verify the validity of information, understand technological limitations, and apply AI ethically and responsibly (Cotton et al., 2024; Miao & Cukurova, 2024; UNESCO, 2023). UNESCO incorporates these competencies into an AI competency framework for teachers, which encompasses a human-centered mindset, AI ethics, AI-based pedagogy, and professional readiness to navigate AI advancements (Harsanti et al., 2025; Miao et al., 2021; UNESCO, 2023). Consequently, strengthening teacher competence is crucial for achieving SDG 4, as the quality of education relies heavily on teachers' ability to effectively utilize technology to support the learning process.

Various training and community service initiatives have been conducted to enhance teachers' understanding of AI. These programs generally focus on introducing generative AI, utilizing chatbots such as ChatGPT and Gemini, and developing teaching materials, assessments, and learning media, as well as prompt engineering techniques (Apoko, 2025; Pambudi et al., 2025; Syamsuri et al., 2025; Widhiyanto et al., 2025). Results indicate an improvement in teachers' understanding and motivation regarding the use of AI in education. However, most programs remain focused on using AI as a generative tool to boost teacher productivity. Training specifically addressing information verification, source tracing, mitigating the risk of "hallucinations," and responsible AI usage remains relatively limited (Kurniawan, 2026).

Addressing this gap is vital because quality education requires not only access to technology but also the ability to use it critically and based on evidence. One approach with the potential to meet this need is "grounded AI." Unlike generative AI, which produces answers based on a model's general knowledge, grounded AI generates output based on sources or documents explicitly provided by the user (Ji et al., 2024) . This approach allows for the traceability of information origins, thereby facilitating source verification and information validation. It aligns with UNESCO recommendations emphasizing the importance of transparent, auditable AI usage that supports responsible learning (Miao et al., 2021; UNESCO, 2023) . Furthermore, this approach fosters information literacy, source evaluation capabilities, and critical thinking skills that are essential components of 21st-century competencies (Bakkenes et al., 2010; Kasneci et al., 2023; Luckin & Holmes, 2016; UNESCO, 2023). One platform implementing the grounded AI approach is Notebook (formerly known as NotebookLM). This platform enables users to upload documents as primary sources, ensuring that any AI-generated answers, summaries, or analyses can be traced back to the specific references used. These characteristics make the notebook relevant to the world of education, as it enables users to obtain information that is more transparent, accurate, and accountable (Leon, 2025).

SMA Al-Abidin Bilingual School (ABBS) Surakarta is committed to educational innovation and the integration of digital technology into the learning process. However, a needs assessment revealed varying levels of AI proficiency among the teaching staff. While some teachers already utilize AI in their professional activities, others require further competency development—specifically regarding the ability to use AI critically, ethically, and based on reliable sources. Furthermore, the ability to verify information and mitigate the risk of AI "hallucinations" is not yet consistently demonstrated across the faculty.

In response to this situation, this community service initiative was conducted as a "Grounded AI" workshop utilizing Notebooks for teachers at SMA Al-Abidin Bilingual School Surakarta. Unlike general AI training sessions that focus on broad applications of generative AI, this workshop emphasized strengthening teachers' competencies in using AI grounded in verifiable sources to minimize the risks of hallucinations and misinformation. The initiative aimed to enhance teachers' AI literacy, introduce the Grounded AI approach, provide training on using Notebooks to support learning based on reliable sources, and reinforce the ability to use AI critically, ethically, and responsibly. Finally, this activity is expected to support the achievement of SDG 4 by strengthening the competencies of teachers as key agents in delivering quality, inclusive, and sustainable education.

2. METHOD

This community service program involved all teachers from various disciplines at SMA Al-Abidin Bilingual School (ABBS) Surakarta. The planning phase was conducted collaboratively by the team and the school. The community service activity followed a process flow comprising preparation, implementation, and evaluation, as illustrated in Figure 1.

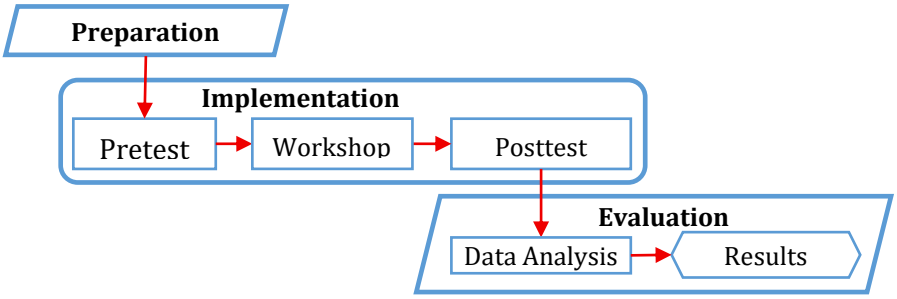


Figure 1. The process flow

A. Preparation

During the preparation stage, the service team coordinated with SMA ABBS regarding the selection of materials, participants, and the schedule. After identifying the school's needs, the team began gathering and compiling the workshop materials.

B. Implementation

The workshop took place at SMA ABBS Surakarta during June and July 2026. A few days prior to the workshop, participants were required to complete a pre-test via an online questionnaire. The service activity was conducted as a workshop session featuring lectures, Q&A sessions, and hands-on practice. Following the workshop, participants completed a post-test containing questions similar to those in the pre-test.

C. Evaluation.

This community service program was evaluated primarily using quantitative methods. Pre-test and post-test data were statistically analyzed using a paired-sample Student's t-test with

an alpha level of 5%. All statistical analyses were conducted on JASP (JASP Team, 2026). The results were used to determine the impact of the workshop. In addition to quantitative analysis, unstructured observations were conducted during the workshop to gauge participant responses.

The questionnaires used for the pre-test and post-test covered five competency aspects, broken down into a total of 16 statements. Each statement was measured using a 1–5 Likert scale, where 1 indicated the lowest level of suitability or agreement, and 5 indicated the highest ones. The pre-test and post-test questionnaires are presented in Table 1.

Tabel 1. The questionnaires used for the pre-test and post-test

No	Item	Aspect
1	I understand the AI ecosystem and how its components function.	(A) Basic AI Literacy
2	I understand the concept of Grounded AI, where the AI responds solely based on a specific set of documents I have designated.	
3	I can extract key points from personal documents to create a presentation outline using AI.	(B) Preparation and Development of Teaching Materials
4	I can draft accurate presentation text—free from hallucinations—by referencing source documents directly.	
5	I can use AI to map relationships between concepts without hallucinations.	
6	I can create a hierarchical concept map structure where every point can be traced back to a specific page in the original document.	
7	I can construct a presentation storyboard where every argument cites the original reference.	
8	I can draft speaker notes that are firmly grounded in research literature using AI.	
9	I can manage various document formats (PDFs, links, text) within a single, dedicated workspace.	(C) Knowledge Management and Classroom Implementation
10	I can create a "Virtual Tutor" chatbot for students using references I have personally validated.	
11	I can use assessment rubrics and student answer sheets as the definitive reference (ground truth) for the AI.	(D) Learning Evaluation and Feedback
12	I can use AI to evaluate student answers objectively and rigorously based on rubric criteria.	
13	I can draft evaluation feedback that references specific sentences from student answer sheets.	
14	I can synthesize many research journals simultaneously without the risk of the AI generating fictitious references.	(E) Professional Development
15	I can leverage source-based AI features to quickly grasp the essence of a large volume of research literature.	
16	I am able to prepare an initial draft of a scientific paper that includes citation references from the uploaded literature.	

3. RESULT AND DISCUSSION

Result

A total of 60 teachers participated in the grounded AI workshop at SMA ABBS Surakarta. However, only 39 participants completed both the pre-test and post-test questionnaires. Because the evaluation employed a paired-sample design, only complete paired responses were included in the statistical analysis. Consequently, all inferential analyses were conducted using 39 matched observations. The pre-test and post-test responses were first averaged to obtain scores for each competency domain (A–E) as well as an overall competence score. These aggregated scores formed the basis of the subsequent statistical analyses, while the descriptive statistics are

presented in Table 2. Prior to hypothesis testing, normality of the paired differences was assessed using the Shapiro-Wilk test, and the results are summarized in Table 3.

Table 2. Descriptive statistic of pretest and posttest

	N	Mean	SD	SE	Coef of variation
pre_A	39	2.821	0.831	0.133	0.295
post_A	39	3.795	0.483	0.077	0.127
pre_B	39	2.863	0.815	0.131	0.285
post_B	39	3.940	0.509	0.082	0.129
pre_C	39	2.654	0.875	0.140	0.330
post_C	39	3.731	0.647	0.104	0.174
pre_D	39	2.855	0.748	0.120	0.262
post_D	39	4.077	0.538	0.086	0.132
pre_E	39	2.564	0.750	0.120	0.292
post_E	39	3.991	0.619	0.099	0.155
Pre_All	39	2.774	0724	0.166	0.261
Post_All	39	3.931	0.388	0.062	0.099

Table 3. Shapiro-Wilk Normality Test

			W	p
pre_A	-	post_A	0.916	0.007
pre_B	-	post_B	0.953	0.105
pre_C	-	post_C	0.917	0.007
pre_D	-	post_D	0.957	0.137
pre_E	-	post_E	0.972	0.417
Pre_All	-	Post_All	0.955	0.117

The analysis indicates that the distributions of paired differences for aspects B, D, E, and the overall score did not significantly deviate from normality ($p > 0.05$), whereas aspects A and C showed significant deviations ($p < 0.05$). Nevertheless, the paired-sample t-test was retained because it is generally robust to moderate departures from normality (Lumley et al., 2002; Park et al., 2020) , particularly when sample sizes exceed 30 observations (Ghasemi & Zahediasl, 2012) . Furthermore, the results were corroborated using the non-parametric Wilcoxon signed-rank test, which yielded the same conclusion across all competency domains. The paired samples T-test is shown in Table 4.

Table 4. Paired Samples T-Test

Measure 1		Measure 2	Test	t	Z	df	p	Effect size (Cohen's *d*)
pre_A	-	post_A	Student	-8.190		38	<0.001	-1.311
			Wilcoxon		-5.012		<0.001	
pre_B	-	post_B	Student	-12.260		38	<0.001	-1.963
			Wilcoxon		-5.442		<0.001	
pre_C	-	post_C	Student	-10.124		38	<0.001	-1.621
			Wilcoxon		-5.232		<0.001	
pre_D	-	post_D	Student	-11.136		38	<0.001	-1.783
			Wilcoxon		-5.232		<0.001	
pre_E	-	post_E	Student	-12.956		38	<0.001	-2.075
			Wilcoxon		-5.303		<0.001	

Pre_All	-	Post_All	Student	-15.882		38	<0.001	-2.543
			Wilcoxon		-5.442		<0.001	

The overall results indicate a substantial improvement in teacher competence following the workshop. The aggregate mean score increased from 2.774 in the pre-test to 3.931 in the post-test. A paired-sample t-test confirmed that the improvement was statistically significant ($t = -15.882$, $p < 0.001$), with a very large effect size (Cohen's $d = 2.543$). These results indicate that the grounded AI workshop produced a strong positive effect on participants' perceived competence.

The distributional shift between pre-test and post-test scores can also be observed visually in the raincloud plot presented in Figure 2. Most participants exhibited higher post-test scores, while score variability decreased after the workshop, indicating a more consistent level of competence among participants. To provide a more detailed understanding of the workshop outcomes, the analysis was conducted across five competency domains: (A) Basic AI Literacy, (B) Preparation and Development of Teaching Materials, (C) Knowledge Management and Classroom Implementation, (D) Learning Evaluation and Feedback, and (E) Professional Development. All domains demonstrated statistically significant improvements ($p < 0.001$).

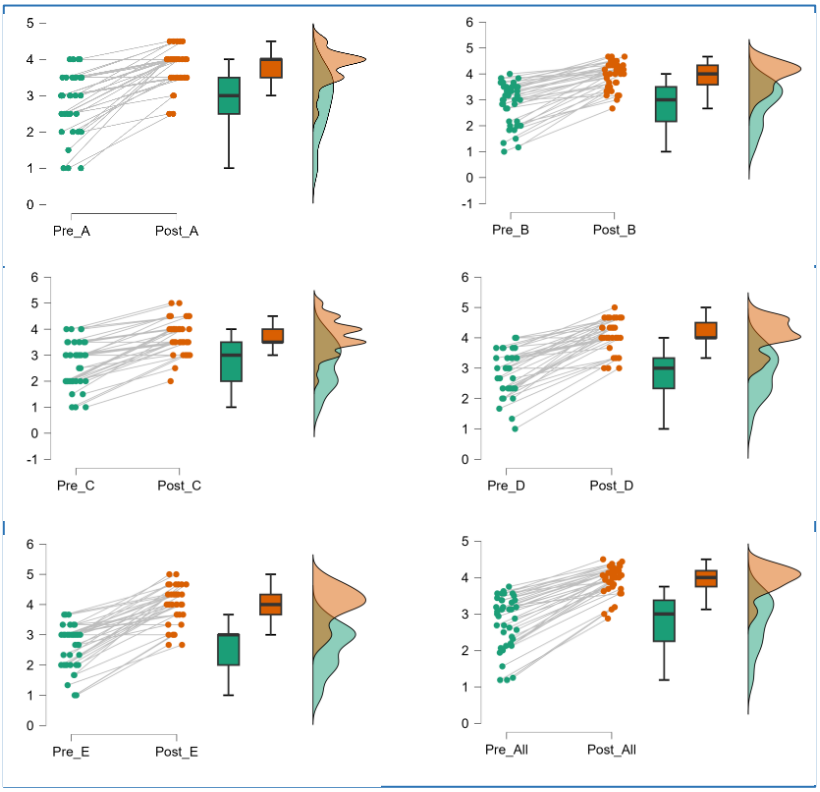


Figure 2. Visualization of pretest and posttest

The Basic AI Literacy (A) domain showed a significant increase from a mean score of 2.821 before the workshop to 3.795 afterward. The paired-sample t-test yielded a large effect size ($d = 1.311$), indicating substantial growth in participants' understanding of AI concepts and the principles of grounded AI.

The Preparation and Development of Teaching Materials (B) domain improved from 2.863 to 3.940 and produced a very large effect size ($d = 1.963$). This domain showed one of the strongest improvements among all measured competencies, suggesting that participants quickly

recognized how grounded AI could support lesson preparation, concept mapping, presentation development, and the creation of evidence-based teaching materials.

The Knowledge Management and Classroom Implementation (C) domain increased from 2.654 to 3.731 with a very large effect size (d = 1.621). This finding indicates that participants developed stronger confidence in organizing multiple information sources within a single workspace and in implementing source-grounded AI tools to support classroom activities. Nevertheless, this domain achieved the lowest post-test mean score among the five aspects, suggesting that competence in classroom-level implementation may require additional practice beyond the workshop.

The Learning Evaluation and Feedback (D) domain showed a substantial increase from 2.855 to 4.077. The resulting effect size (d = 1.783) indicates a very strong improvement in teachers' confidence regarding AI-assisted assessment, rubric-based evaluation, and the generation of feedback grounded in authentic evidence. Notably, this domain obtained the highest post-test mean score among all aspects.

The strongest improvement was observed in the Professional Development (E) domain. The mean score increased from 2.564 in the pre-test to 3.991 in the post-test, while the effect size reached d = 2.075. This was the largest effect size among all competency domains, indicating that participants perceived considerable benefits from grounded AI in literature review, research synthesis, and scientific writing activities.

When ranked by effect size, the domains can be ordered as follows: Professional Development (E; d = 2.075), Preparation and Development of Teaching Materials (B; d = 1.963), Learning Evaluation and Feedback (D; d = 1.783), Knowledge Management and Classroom Implementation (C; d = 1.621), and Basic AI Literacy (A; *d* = 1.311). This finding suggests that the workshop generated the strongest impact on practical and immediately applicable activities, particularly research-related tasks and instructional material development.

Discussion

The findings demonstrate that the grounded AI workshop effectively enhanced participants' competencies across all measured domains. The overall competence score increased substantially from 2.774 to 3.931, with a very large effect size (d = 2.543), indicating that the intervention produced meaningful learning gains. This result aligns with teacher professional development literature, which suggests that meaningful learning occurs when educators engage directly with innovations that address authentic professional needs. Bakkenes et al. found that educational innovation can stimulate substantial teacher learning when teachers actively experiment with new practices (Bakkenes et al., 2010), while Guskey emphasized that effective professional development should lead to observable changes in teachers' knowledge and practice (Guskey, 2002). The present workshop provided such opportunities through hands-on activities using grounded AI in authentic educational tasks.

The largest improvement was observed in the Professional Development domain (d = 2.075), followed by Preparation and Development of Teaching Materials (d = 1.963). These findings suggest that teachers perceived grounded AI as particularly valuable for research-related activities, literature review, academic writing, and instructional material development. This result is consistent with national evidence showing that Indonesian teachers increasingly utilize AI for information retrieval, lesson preparation, and professional learning, although they often remain concerned about the reliability of AI-generated outputs (Aisyah et al., 2026; Mulyani et al., 2025; Widhiyanto et al., 2025) . Unlike conventional generative AI systems, grounded AI enables users to work directly with selected source documents, thereby reducing the likelihood of hallucinated information and fictitious references (Cotton et al., 2024) . This

characteristic may explain why the strongest gains occurred in activities that depend heavily on information accuracy and source traceability.

Substantial improvements were also observed in the Learning Evaluation and Feedback domain (d = 1.783), which achieved the highest post-test score among all domains. This finding indicates that teachers viewed grounded AI as a useful mechanism for supporting assessment processes through the use of rubrics, student responses, and other validated references as explicit sources. The result supports UNESCO's recommendation that AI should augment rather than replace teacher judgment and should operate within transparent and accountable educational processes. Furthermore, previous studies involving Indonesian teachers have highlighted concerns regarding academic integrity, ethical AI use, and the trustworthiness of AI-generated outputs (Husna & Zakiah, 2025; Kurniawan, 2026; Susilowati et al., 2025; Zhang et al., 2026) . The present findings suggest that source-based AI may help address some of these concerns by making evaluation processes more evidence-based and explainable.

Although the Knowledge Management and Classroom Implementation domain improved significantly (d = 1.621), it remained the lowest-performing domain after the workshop. The Basic AI Literacy domain also showed the smallest effect size (d = 1.311). These findings suggest that teachers may adopt concrete applications of AI more readily than broader classroom integration strategies or conceptual understanding of AI systems (Zhang et al., 2026). Similar patterns have been reported in previous studies, where teachers generally expressed positive attitudes toward AI but remained less confident about integrating it into day-to-day classroom practice (Darko et al., 2026; Harsanti et al., 2025; Moh et al., 2025). Consequently, future training initiatives should move beyond introductory workshops and provide sustained mentoring focused on classroom implementation, instructional redesign, and AI-supported learning environments (Guskey, 2002).

Overall, the findings suggest that grounded AI offers a practical pathway for strengthening teacher competence while simultaneously addressing concerns related to hallucination, misinformation, and source reliability. This finding is consistent with UNESCO's vision of human-centered and responsible AI in education, which emphasizes transparency, critical evaluation, and ethical use of technology (Miao et al., 2021; Miao & Cukurova, 2024; UNESCO, 2022, 2023). By strengthening teachers' abilities to verify information and utilize AI in an evidence-based manner (Saini et al., 2023) , the workshop contributes not only to AI adoption but also to the broader goals of SDG 4, namely improving educational quality and supporting lifelong learning among educators.

4. CONCLUSION

This community service program successfully strengthened teachers' competencies in using grounded AI through a workshop conducted at SMA Al-Abidin Bilingual School (ABBS) Surakarta. Statistical analysis demonstrated significant improvements across all measured competency domains, including Basic AI Literacy, Preparation and Development of Teaching Materials, Knowledge Management and Classroom Implementation, Learning Evaluation and Feedback, and Professional Development. The largest improvements were observed in Professional Development and Preparation and Development of Teaching Materials, indicating that participants perceived grounded AI as particularly beneficial for research-related activities, academic writing, and the development of evidence-based learning resources. Meanwhile, competencies related to classroom implementation, although significantly improved, still require further strengthening through continued practice and mentoring.

The findings suggest that grounded AI provides a practical approach for addressing common concerns associated with generative AI, particularly hallucination, misinformation,

and source reliability. By emphasizing source traceability and evidence-based AI usage, the workshop contributed not only to the enhancement of teachers' AI competencies but also to the broader objective of SDG 4, namely improving the quality of education through responsible and informed technology adoption. Future programs should move beyond introductory workshops and provide sustained support focused on classroom implementation, AI-supported learning environments, and long-term pedagogical integration.

5. ACKNOWLEDGEMENT

This community service activity is fully funded by Universitas Sebelas Maret under the PKM HGR scheme, with contract number 463/UN27.22/PT.01.03/2026.

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