

GENERATIVE AI LITERACY FOR ISLAMIC COMMUNICATION AND STEM TEACHING: A NOTEBOOKLM TRAINING STUDY FOR ELEMENTARY SCHOOL TEACHERS

Nur Choiro Siregar, Nurhayati, Yani Sugiyani, Ri Sabti Septarini, Dedy Alamsyah

Department of Informatics Engineering, Universitas Muhammadiyah Tangerang, Indonesia

Email: nur.choiro@umt.ac.id

Abstract

This conceptual paper explores how generative AI literacy can be strengthened among elementary school teachers through NotebookLM-based training within the integrated context of Islamic communication and STEM teaching. The study responds to the growing need for teachers to use artificial intelligence not only as a technological tool, but also as a pedagogical and ethical medium for communicating knowledge in meaningful, responsible, and value-based ways. Using an integrative literature-based conceptual analysis, this paper synthesizes key ideas from generative AI literacy, Islamic communication, digital da'wah, STEM pedagogy, ethical AI use, and teacher professional development. The conceptual development process involves four stages: identifying core concepts, reviewing relevant literature, mapping relationships among generative AI literacy, Islamic communication, and STEM teaching, and constructing a proposed NotebookLM-based training framework. The framework consists of three main competencies: AI literacy competence, Islamic communication competence, and STEM pedagogical competence. AI literacy competence emphasizes teachers' ability to understand, evaluate, and use generative AI critically and responsibly. Islamic communication competence highlights truthfulness, clarity, wisdom, ethical responsibility, and beneficial communication. STEM pedagogical competence focuses on designing interdisciplinary learning activities that connect science, technology, engineering, and mathematics in elementary education. This paper proposes that NotebookLM-based training can support teachers in organizing teaching resources, generating STEM lesson ideas, evaluating AI-generated content, and reflecting on ethical AI use. Although the framework has not yet been empirically tested, it offers a conceptual basis for future qualitative, action research, quasi-experimental, or mixed-method studies. It also contributes to discussions on digital da'wah in contemporary classroom contexts and practice.

Keywords: *Generative AI literacy; Islamic communication; STEM teaching; NotebookLM; Elementary school teachers*

Abstrak

Studi konseptual ini mengeksplorasi bagaimana literasi AI generatif dapat diperkuat di kalangan guru sekolah dasar melalui pelatihan berbasis NotebookLM dalam konteks terpadu komunikasi Islam dan pengajaran STEM. Studi ini menanggapi meningkatnya kebutuhan guru untuk menggunakan kecerdasan buatan tidak hanya sebagai alat teknologi, namun juga sebagai media pedagogis dan etis untuk mengkomunikasikan pengetahuan dengan cara yang bermakna, bertanggung jawab, dan berbasis nilai. Dengan menggunakan analisis konseptual berbasis literatur integratif, makalah ini mensintesis ide-ide utama dari literasi AI generatif, komunikasi Islam, dakwah digital, pedagogi STEM, penggunaan AI yang etis, dan pengembangan profesional guru. Proses pengembangan konseptual melibatkan empat tahap: mengidentifikasi konsep inti, meninjau literatur yang relevan, memetakan hubungan antara literasi AI generatif, komunikasi Islami, dan

©2026 The authors and Komunika. All rights reserved.

Article Information:

Received Juni 28, 2026 Revised Juni 30, 2026 Accepted Juni 30, 2026

pengajaran STEM, dan menyusun kerangka pelatihan berbasis NotebookLM yang diusulkan. Kerangka tersebut terdiri dari tiga kompetensi utama: kompetensi literasi AI, kompetensi komunikasi Islami, dan kompetensi pedagogi STEM. Kompetensi literasi AI menekankan pada kemampuan guru untuk memahami, mengevaluasi, dan menggunakan AI generatif secara kritis dan bertanggung jawab. Kompetensi komunikasi Islam menonjolkan kejujuran, kejelasan, kebijaksanaan, tanggung jawab etis, dan komunikasi yang bermanfaat. Kompetensi pedagogi STEM berfokus pada perancangan kegiatan pembelajaran interdisipliner yang menghubungkan sains, teknologi, teknik, dan matematika pada pendidikan dasar. Makalah ini mengusulkan bahwa pelatihan berbasis NotebookLM dapat mendukung guru dalam mengatur sumber daya pengajaran, menghasilkan ide pelajaran STEM, mengevaluasi konten yang dihasilkan AI, dan merefleksikan penggunaan AI yang etis. Meskipun kerangka ini belum diuji secara empiris, kerangka ini menawarkan dasar konseptual untuk penelitian kualitatif, penelitian tindakan, kuasi-eksperimental, atau metode campuran di masa depan. Hal ini juga berkontribusi pada diskusi tentang dakwah digital dalam konteks dan praktik kelas kontemporer.

Keywords: Literasi AI generatif; Komunikasi islam; Pengajaran STEM; NotebookLM; Guru sekolah dasar

1. Introduction

The rapid development of generative artificial intelligence has created significant changes in the way knowledge is accessed, processed, communicated, and transformed into learning resources (Siregar et al., 2025). In education, generative AI is no longer viewed merely as an advanced technological innovation (Kronblad et al., 2024; Sedkaoui & Benaichouba, 2026; Storey et al., 2025; Trigka & Dritsas, 2025), but also as a pedagogical instrument that can support teachers in designing learning materials, generating instructional ideas, developing assessments, and facilitating students' understanding of complex concepts. The emergence of large language models and AI-based learning tools has encouraged educators to reconsider the meaning of digital competence in contemporary classrooms. Kasneci et al. (2023) explain that large language models provide new opportunities for education because they can support content generation, personalized learning, feedback, and teacher preparation. However, they also emphasize that the use of such tools requires critical awareness, ethical reflection, and pedagogical control. Therefore, teachers need not only technical ability to operate AI tools, but also literacy to evaluate their accuracy, relevance, bias, and ethical implications.

Generative AI literacy has become increasingly important because teachers are positioned as key actors in determining how AI is integrated into learning. AI literacy refers to the ability to understand, use, evaluate, and critically reflect on artificial intelligence technologies in social and educational contexts. Ng et al. (2021) argue that AI literacy includes knowledge of AI concepts, the ability to apply AI tools, the capacity to evaluate AI outputs, and awareness of ethical issues surrounding AI use. In the context of elementary education, this literacy is especially important because teachers guide young learners who are still developing foundational knowledge, values, reasoning skills, and digital habits. When teachers lack AI literacy, generative AI may be used only for technical convenience, such as producing instant lesson content, without adequate evaluation of its pedagogical and ethical quality (Haroud & Saqri, 2025; Nguyen, 2025; Wang et al., 2024). Conversely, when teachers develop strong AI literacy,

AI can become a supportive tool for improving instructional creativity, critical thinking, and reflective teaching practice.

The need for AI literacy is also relevant in K–12 and elementary school contexts. Casal-Otero et al. (2023) state that AI literacy has become a pedagogical and cognitive challenge in K–12 education because students increasingly live in environments shaped by intelligent systems. This condition suggests that schools must prepare both teachers and students to understand AI not only as a tool, but also as a social and cultural phenomenon. Elementary school teachers require practical and conceptual support to integrate AI into classroom activities in age-appropriate, ethical, and meaningful ways (Adams et al., 2023; Busuttil, 2025; Lee, 2026). In this regard, teacher training becomes a central strategy for strengthening generative AI literacy. Training should not only introduce AI platforms, but also develop teachers' ability to formulate prompts, evaluate generated information, adapt AI outputs to curriculum needs, and ensure that AI-supported materials remain aligned with educational values.

The discussion of generative AI in teacher education is closely related to recent studies on ChatGPT and other AI tools in education. Lo (2023) shows that ChatGPT has potential benefits for education, including supporting writing, answering questions, generating examples, and assisting learning across different subject areas. However, the same study also highlights several concerns, such as inaccurate information, academic integrity, overdependence, and uneven performance across disciplines. Chiu (2024) further explains that generative AI affects educational practices, policies, and research directions, particularly because it changes the relationship between teachers, students, learning resources, and assessment. These findings indicate that the use of generative AI in education should not be separated from teacher readiness. Teachers need structured professional development that helps them use AI as a reflective partner rather than as an automatic replacement for pedagogical judgment.

In this conceptual paper, NotebookLM is positioned as one possible AI-supported tool for teacher training. NotebookLM-based training can help teachers organize learning resources, summarize materials, generate lesson ideas, and reflect on teaching content based on uploaded sources. Unlike general AI use that may rely on broad and uncontrolled prompts, a source-based AI tool can encourage teachers to work with specific teaching materials and evaluate outputs in relation to selected references. This is important for elementary school teachers because they often need to simplify complex information into language and activities that are suitable for young learners. Through NotebookLM-based training, teachers can be guided to upload curriculum documents, teaching modules, Islamic communication materials, and STEM resources, then use AI to support the development of integrated lesson plans. However, the use of NotebookLM still requires teacher literacy, because AI-generated summaries and suggestions must be reviewed, contextualized, and ethically adapted before being used in the classroom.

The integration of generative AI literacy with Islamic communication provides a distinctive contribution to the field of communication science and Islamic da'wah.

Islamic communication emphasizes the delivery of messages in ways that are truthful, clear, wise, ethical, and beneficial. In educational contexts, communication is not limited to the transmission of information; it also involves character formation, moral guidance, and the cultivation of responsible behavior. Saleh et al. (2022) explain that digital transformation has changed the method and culture of Islamic communication, making da'wah increasingly connected to digital media and contemporary communication practices. This transformation creates opportunities for Islamic messages to reach wider audiences, but it also requires ethical awareness so that religious communication does not lose its moral foundation in digital spaces.

Digital da'wah has become increasingly relevant in the contemporary era because Islamic communication now occurs through various digital platforms, learning media, and online communities. Aslan and Pong (2023) show that digital da'wah practices in Indonesia have developed through social media and online video platforms, indicating that religious communication is increasingly mediated by digital technologies. In education, this shift suggests that Islamic values can also be communicated through digital learning tools, including AI-supported platforms. However, the integration of AI into Islamic communication should not be understood as replacing human moral responsibility. Instead, AI should be positioned as a supporting medium that helps teachers organize and communicate knowledge while maintaining ethical values such as honesty, wisdom, responsibility, and usefulness.

The relationship between Islamic communication and generative AI literacy is important because AI-generated content may contain inaccuracies, biases, inappropriate framing, or messages that do not align with Islamic educational values. Therefore, teachers must be able to evaluate whether AI-supported materials are accurate, respectful, pedagogically appropriate, and ethically responsible. In Islamic communication, the teacher's role is not only to deliver information, but also to ensure that communication leads to beneficial understanding. Rasiam et al. (2023) highlight the relevance of prophetic communication in new media contexts, particularly in relation to ethical message delivery and public engagement. This idea can be extended to classroom communication, where teachers are expected to use digital tools in ways that support moral clarity and social benefit. Thus, generative AI literacy for Islamic communication requires the combination of technical skill, critical evaluation, and ethical responsibility.

At the same time, this study connects generative AI literacy and Islamic communication with STEM teaching. STEM education encourages the integration of science, technology, engineering, and mathematics to develop students' problem-solving skills, creativity, collaboration, and critical thinking (Siregar et al., 2025, 2026). In elementary education, STEM teaching is important because it helps students understand real-world problems through interdisciplinary learning activities. However, STEM integration can be challenging for teachers because it requires the ability to connect concepts across subjects, design inquiry-based tasks, and develop contextual learning experiences. Abd Ghani et al. (2023) emphasize

that professional development programs are necessary for science and mathematics primary school teachers because effective STEM education requires teachers who are knowledgeable, skilled, and prepared to design integrated learning. This indicates that teacher training is essential for improving STEM teaching quality at the elementary level.

Recent research also supports the importance of professional development for STEM teachers. Zhou et al. (2023) found that professional development has a strong effect on in-service STEM teachers' self-efficacy in K–12 contexts. This finding is relevant because teachers' confidence influences their willingness to experiment with new instructional models, including AI-supported STEM learning. When teachers feel more competent in designing STEM lessons, they are more likely to create interdisciplinary activities that encourage students to ask questions, investigate problems, and apply knowledge creatively. Generative AI can support this process by helping teachers brainstorm STEM scenarios, simplify scientific explanations, generate inquiry questions, and design project-based tasks. However, without sufficient AI literacy, teachers may use AI outputs passively rather than critically. Therefore, STEM professional development and AI literacy training should be integrated rather than separated.

The combination of generative AI literacy, Islamic communication, and STEM teaching offers a valuable conceptual direction for elementary teacher professional development. In many discussions, AI in education is treated mainly as a technological or instructional issue. However, in Islamic educational contexts, AI integration must also be connected to communication ethics, value transmission, and moral responsibility. Similarly, STEM teaching should not be limited to technical problem solving; it can also be connected to ethical awareness, social responsibility, and meaningful communication. This conceptual paper argues that elementary school teachers need a training framework that enables them to use generative AI for STEM teaching while remaining guided by Islamic communication principles. Such a framework can help teachers become not only users of AI tools, but also ethical communicators and reflective designers of interdisciplinary learning.

Despite growing research on AI in education, AI literacy, digital da'wah, and STEM professional development, there remains a conceptual gap in connecting these areas into a single teacher training framework. Studies on generative AI often focus on higher education, student use, assessment, or academic writing, while studies on STEM professional development often focus on science and mathematics instruction without specifically addressing Islamic communication. Likewise, digital da'wah studies commonly discuss social media and public religious communication, but fewer studies examine how Islamic communication principles can guide teachers' use of generative AI in STEM classrooms. This gap shows the need for a conceptual model that integrates AI literacy competence, Islamic communication competence, and STEM pedagogical competence.

Based on this background, this paper aims to develop a conceptual foundation for NotebookLM-based training designed to strengthen elementary school teachers'

generative AI literacy in the context of Islamic communication and STEM teaching. The paper does not present empirical findings from fieldwork, but offers a literature-based conceptual analysis that can guide future teacher training, classroom innovation, and empirical research. The proposed framework is expected to contribute to communication science and Islamic da'wah by showing how AI-supported learning can become a medium for ethical, value-based, and beneficial communication. It also contributes to STEM education by proposing a teacher training direction that supports interdisciplinary lesson design through responsible use of generative AI. In this way, the study positions NotebookLM-based training as a conceptual bridge between technological literacy, Islamic communication ethics, and STEM pedagogical practice in elementary education.

2. Literature review

2.1 Generative AI Literacy in Teacher Education

Generative artificial intelligence has become an important issue in contemporary teacher education because it changes how teachers access information, prepare learning materials, communicate ideas, and support students' learning processes. In the educational context, generative AI refers to artificial intelligence systems that can produce text, explanations, summaries, examples, questions, and learning resources based on user prompts. The emergence of these tools requires teachers to develop not only technical skills, but also critical and ethical awareness. Kasneci et al. (2023) explain that large language models can support education by assisting content generation, feedback, tutoring, and teacher preparation. However, these opportunities are accompanied by challenges such as inaccurate information, bias, lack of transparency, and possible overdependence on AI-generated outputs. Therefore, teachers need generative AI literacy to use AI tools critically and responsibly.

AI literacy generally refers to the ability to understand, use, evaluate, and reflect on AI technologies. Ng et al. (2021) conceptualize AI literacy as a multidimensional competence that includes knowing and understanding AI, applying AI, evaluating AI, and considering ethical issues related to AI use. This definition is important for teacher education because teachers are not only users of technology, but also mediators of knowledge and values in the classroom. In elementary education, teachers must be able to decide whether AI-generated content is appropriate for students' cognitive level, curriculum objectives, and moral development. Without sufficient AI literacy, teachers may simply copy AI outputs without verifying accuracy, relevance, or ethical suitability. With adequate AI literacy, however, generative AI can support reflective teaching, lesson planning, and the development of more engaging learning resources.

The importance of AI literacy is also highlighted in K–12 education. Casal-Otero et al. (2023) found that AI literacy has become a growing pedagogical concern because students increasingly interact with AI-based systems in daily life. Their systematic literature review shows that AI education in K–12 contexts should not be limited to technical programming skills, but should also include critical understanding, social awareness, and ethical reflection. This view is relevant to

elementary school teachers because they need to introduce digital and AI-related concepts in a way that is meaningful and age-appropriate. Teacher professional development is therefore necessary to help teachers understand how AI works, how AI can support learning, and how its limitations should be communicated to students.

Generative AI tools such as ChatGPT and other large language models have also influenced educational practice. Lo (2023) shows that ChatGPT can support learning by generating explanations, answering questions, assisting writing, and providing learning examples. Nevertheless, the same study notes that ChatGPT's performance varies across disciplines and that its outputs may contain inaccuracies. Chiu (2024) also argues that generative AI has implications for educational practices, policies, and research because it changes the roles of teachers, students, and learning resources. These studies indicate that teachers should not view generative AI as an automatic solution, but as a tool that requires human judgment. In this sense, generative AI literacy becomes a foundation for responsible integration of AI into teaching.

2.2 NotebookLM-Based Training as AI-Supported Professional Development

NotebookLM-based training can be understood as a form of AI-supported professional development that helps teachers interact with selected learning resources. In this conceptual paper, NotebookLM is positioned as a tool that can support teachers in organizing materials, summarizing sources, generating teaching ideas, and reflecting on instructional content. Compared with general AI use, source-based AI tools may encourage teachers to work with specific documents, modules, curriculum materials, and references. This feature is useful because teachers can connect AI outputs with the actual learning resources they use in the classroom.

Teacher training is essential because the educational benefits of AI depend heavily on how teachers understand and apply the technology. Professional development should not only introduce the technical features of AI platforms, but also train teachers to formulate prompts, evaluate generated responses, revise AI-supported materials, and adapt outputs to students' needs. Abd Ghani et al. (2023) emphasize that professional development programs are important for primary school teachers because they improve teachers' knowledge, confidence, and instructional readiness. In the context of generative AI, professional development can help teachers move from passive users of technology to critical designers of AI-supported learning.

NotebookLM-based training can be designed through several activities. First, teachers can be introduced to the basic concept of generative AI and its role in education. Second, teachers can be guided to upload teaching materials, STEM resources, and Islamic communication content. Third, teachers can practice generating summaries, lesson ideas, inquiry questions, and classroom activities. Fourth, teachers can evaluate AI-generated outputs by checking accuracy, curriculum alignment, ethical suitability, and clarity of communication. Fifth,

teachers can reflect on how AI use can support responsible and meaningful teaching. This training model is consistent with the idea that AI literacy should include technical, pedagogical, and ethical dimensions (Ng et al., 2021).

2.3 Islamic Communication and Digital Da'wah in Education

Islamic communication provides an ethical foundation for the use of generative AI in education. Communication in Islam is not merely the delivery of information, but also a moral act that should be guided by truthfulness, clarity, wisdom, responsibility, and benefit. In the context of teaching, Islamic communication requires teachers to communicate knowledge in ways that are meaningful, respectful, and ethically accountable. This principle is important when teachers use AI-generated content because AI may produce information that is inaccurate, biased, or inconsistent with Islamic values.

The development of digital media has transformed the practice of Islamic communication and da'wah. Saleh et al. (2022) explain that digital transformation has changed the culture and method of da'wah by expanding the use of media, internet-based communication, and digital platforms. This transformation creates opportunities for Islamic messages to reach wider audiences, but it also raises ethical challenges related to cyberculture, hyperreality, and digital misinformation. In education, these challenges are also relevant because teachers increasingly use digital tools to communicate knowledge and values to students.

Digital da'wah is not limited to formal religious preaching; it can also be reflected in educational practices that communicate Islamic values through learning activities. Aslan and Pong (2023) show that digital da'wah practices in Indonesia have increasingly developed through online platforms and social media. Although their study focuses on Muslim housewives, the broader implication is that Islamic communication has become more digitally mediated. In classroom contexts, teachers can use digital tools, including generative AI, to support value-based communication. However, the use of AI must remain guided by Islamic ethical principles so that technology supports, rather than weakens, moral education.

Prophetic communication also offers a relevant ethical perspective. Rasiam et al. (2023) argue that prophetic communication in new media emphasizes ethical message delivery, public benefit, and responsible communication. This perspective can be applied to teacher communication in the classroom. When teachers use AI to prepare STEM lessons or Islamic learning materials, they must ensure that the message remains truthful, beneficial, and appropriate for students. Therefore, Islamic communication competence should become one of the core components of generative AI literacy training for elementary school teachers.

2.4 STEM Teaching in Elementary Education

STEM teaching integrates science, technology, engineering, and mathematics to develop students' problem-solving skills, creativity, collaboration, and critical thinking. In elementary education, STEM is important because it introduces

students to interdisciplinary thinking from an early age. Rather than teaching science and mathematics as separate subjects, STEM learning encourages students to understand real-life problems through investigation, design, experimentation, and reasoning. This approach can make learning more meaningful because students are invited to connect classroom knowledge with everyday experiences.

However, STEM implementation in elementary schools often creates challenges for teachers. Teachers may experience difficulty designing interdisciplinary activities, connecting STEM concepts with curriculum standards, and creating learning tasks that are suitable for young students. Abd Ghani et al. (2023) explain that STEM professional development is necessary for science and mathematics primary school teachers because effective STEM instruction requires teachers who are knowledgeable, skilled, and pedagogically prepared. This indicates that STEM teaching cannot be strengthened only through curriculum changes; it also requires continuous teacher support and training.

Professional development can improve teachers' confidence in STEM teaching. Zhou et al. (2023) found that professional development has a positive effect on in-service STEM teachers' self-efficacy. Teacher self-efficacy is important because teachers who feel more confident are more willing to design innovative learning activities, use new technologies, and engage students in inquiry-based learning. In this context, generative AI can support STEM teaching by helping teachers generate problem scenarios, simplify scientific explanations, design project-based activities, and prepare guiding questions. However, AI-supported STEM teaching must be accompanied by teacher evaluation so that the generated content remains accurate and pedagogically appropriate.

Recent studies also indicate that STEM professional development can shape how teachers conceptualize integrated STEM learning. Mesutoglu and Akgündüz (2025) show that professional development can influence teachers' understanding of integrated STEM and support their ability to connect disciplinary knowledge. This is relevant to the proposed framework because NotebookLM-based training can help teachers connect STEM content with Islamic communication values. For example, teachers can design STEM activities related to environmental care, health, technology use, or problem solving while communicating Islamic values such as responsibility, honesty, and benefit for society.

2.5 Conceptual Integration of Generative AI Literacy, Islamic Communication, and STEM Teaching

The integration of generative AI literacy, Islamic communication, and STEM teaching provides a conceptual basis for teacher training in contemporary education. Generative AI literacy enables teachers to use AI tools critically and responsibly. Islamic communication provides ethical guidance so that AI-supported teaching remains truthful, clear, wise, and beneficial. STEM teaching provides the pedagogical context in which AI can be applied to develop interdisciplinary learning activities. These three dimensions are interconnected and should not be treated separately.

In this conceptual framework, AI literacy competence refers to teachers' ability to understand AI, use AI tools, evaluate outputs, and reflect on ethical implications. Islamic communication competence refers to teachers' ability to communicate knowledge based on truthfulness, clarity, wisdom, responsibility, and benefit. STEM pedagogical competence refers to teachers' ability to design interdisciplinary learning that connects science, technology, engineering, and mathematics. NotebookLM-based training can become a bridge among these competencies by providing teachers with practical experience in using AI to organize resources, generate STEM lesson ideas, evaluate content, and reflect on ethical communication.

This literature review shows that existing studies have discussed AI literacy, generative AI in education, digital da'wah, Islamic communication, STEM teaching, and teacher professional development. However, these areas are often discussed separately. There is still limited conceptual discussion on how Islamic communication principles can guide elementary school teachers' use of generative AI for STEM teaching. Therefore, this paper proposes a conceptual model that integrates AI literacy competence, Islamic communication competence, and STEM pedagogical competence through NotebookLM-based teacher training.

3. Method

This study adopts a conceptual paper design that aims to develop a theoretical framework for strengthening elementary school teachers' generative AI literacy through NotebookLM-based training in the context of Islamic communication and STEM teaching. As a conceptual study, this paper does not involve direct data collection from participants, experimental intervention, or statistical analysis. Instead, the study is based on a critical synthesis of existing literature related to generative AI literacy, Islamic communication, digital da'wah, STEM pedagogy, and teacher professional development.

The method used in this paper is an integrative literature-based conceptual analysis. This approach was selected because the topic combines several interdisciplinary fields, namely educational technology, communication studies, Islamic values, and STEM education. The integrative approach allows the paper to connect different theoretical perspectives and formulate a conceptual model that can be used for future empirical research or teacher training programs. The conceptual development process was conducted through four main stages. The first stage was identifying the core concepts relevant to the study. These concepts included generative AI literacy, NotebookLM-assisted learning, Islamic communication, STEM teaching, ethical AI use, teacher professional development, and digital da'wah in education. These concepts were selected because they represent the main dimensions of the proposed framework.

The second stage was reviewing and synthesizing relevant literature. The literature was conceptually examined to understand how generative AI can support teachers in accessing, organizing, summarizing, and transforming knowledge for classroom instruction. In this stage, special attention was given to how AI tools such as

NotebookLM may help teachers develop learning materials, generate lesson ideas, summarize teaching resources, and support reflective teaching practices. The review also considered the importance of Islamic communication principles, such as truthfulness, clarity, ethical responsibility, wisdom, and beneficial communication, in guiding teachers' use of generative AI.

The third stage was mapping the relationship between generative AI literacy, Islamic communication, and STEM teaching. In this stage, the paper analyzed how teachers' ability to use generative AI can support STEM instruction while remaining aligned with Islamic ethical values. Generative AI literacy was positioned as the main competency that enables teachers to use AI critically, ethically, and pedagogically. Islamic communication was positioned as the ethical and communicative foundation, while STEM teaching was positioned as the instructional context in which AI-supported learning can be applied.

The fourth stage was developing a proposed conceptual framework for NotebookLM-based teacher training. The framework consists of three major components: AI literacy competence, Islamic communication competence, and STEM pedagogical competence. AI literacy competence refers to teachers' ability to understand, evaluate, and use generative AI tools responsibly. Islamic communication competence refers to teachers' ability to communicate knowledge ethically, clearly, and meaningfully based on Islamic values. STEM pedagogical competence refers to teachers' ability to design interdisciplinary learning activities that integrate science, technology, engineering, and mathematics in elementary education.

Based on these stages, this paper proposes that NotebookLM-based training can be designed as a professional development model that helps elementary school teachers improve their ability to use generative AI for educational purposes. The training model may include activities such as introducing generative AI concepts, exploring NotebookLM features, uploading and analyzing teaching materials, generating STEM-based lesson ideas, evaluating AI-generated content, and reflecting on the ethical use of AI from an Islamic communication perspective.

The analysis in this paper is interpretive and conceptual. Rather than testing hypotheses, the study aims to construct logical connections among the selected concepts and produce a framework that can guide future research and practice. The validity of the conceptual argument is maintained through theoretical coherence, relevance of concepts, consistency of explanation, and alignment with the focus of communication, Islamic da'wah, and STEM-based education.

As a conceptual paper, this study has limitations. The proposed framework has not yet been empirically tested with elementary school teachers. Therefore, future studies are recommended to examine the framework through qualitative case studies, training-based action research, quasi-experimental designs, or mixed-method research involving elementary school teachers in Islamic or general education settings.

4. Results and Discussion

The conceptual analysis indicates that NotebookLM-based training can be positioned as a professional development model for strengthening elementary school teachers' generative AI literacy in three interconnected domains: AI literacy competence, Islamic communication competence, and STEM pedagogical competence. This framework is developed from the assumption that teachers need more than technical ability to operate AI tools. They also require ethical awareness, communication responsibility, and pedagogical creativity when applying generative AI in classroom practice.

The first conceptual result is the identification of AI literacy competence as the foundation of NotebookLM-based teacher training. AI literacy refers to the ability to understand, use, evaluate, and reflect on AI technologies in meaningful and responsible ways. Ng et al. (2021) explain that AI literacy includes knowing and understanding AI, applying AI, evaluating AI outputs, and considering ethical issues. In this framework, elementary school teachers are expected to understand the basic functions of generative AI, formulate relevant prompts, evaluate AI-generated responses, and adapt AI outputs to students' learning needs. This is important because generative AI may produce inaccurate, biased, or contextually inappropriate content. Kasneci et al. (2023) note that large language models offer educational opportunities, but they also require critical control because of risks related to misinformation, bias, and overreliance. Therefore, NotebookLM-based training should not only teach teachers how to generate content, but also how to verify, revise, and contextualize AI-supported materials.

The second conceptual result is the positioning of Islamic communication competence as the ethical foundation of AI-supported teaching. In this study, Islamic communication is understood as communication that emphasizes truthfulness, clarity, wisdom, responsibility, and benefit. These principles are highly relevant to generative AI use because AI-generated materials must be assessed not only for their technical quality, but also for their moral and communicative appropriateness. Saleh et al. (2022) argue that digital transformation has changed the culture and method of Islamic communication, particularly through the expansion of digital media and internet-based da'wah. This transformation suggests that Islamic communication must respond to new technologies, including AI, without losing its ethical orientation. In classroom contexts, teachers act as communicators of knowledge and values. Therefore, their use of AI must be guided by the responsibility to communicate accurate, beneficial, and value-based messages.

The third conceptual result concerns STEM pedagogical competence. STEM teaching requires teachers to integrate science, technology, engineering, and mathematics into meaningful learning activities. Abd Ghani et al. (2023) emphasize that STEM professional development is needed for primary school teachers because integrated STEM learning requires knowledge, confidence, and pedagogical readiness. In this framework, NotebookLM can support teachers in designing STEM learning by helping them summarize teaching resources, generate interdisciplinary lesson ideas, develop inquiry questions, and connect abstract

concepts with real-life problems. However, AI-supported STEM teaching should not be mechanical. Teachers must evaluate whether the AI-generated lesson ideas are aligned with curriculum objectives, suitable for elementary students, and capable of encouraging inquiry, creativity, and problem solving.

The integration of these three competencies produces a conceptual model in which NotebookLM-based training functions as a bridge between technological literacy, Islamic communication ethics, and STEM pedagogy. This model can be implemented through several training stages. The first stage is the introduction of generative AI and its educational opportunities and limitations. The second stage is the exploration of NotebookLM features, especially source-based summarization and material organization. The third stage is the use of NotebookLM to generate STEM teaching ideas based on uploaded teaching materials. The fourth stage is the evaluation of AI-generated content using criteria of accuracy, curriculum relevance, ethical appropriateness, and communicative clarity. The fifth stage is reflective discussion on how AI can be used in accordance with Islamic communication principles. This sequence reflects the idea that AI literacy should include technical, evaluative, and ethical dimensions (Ng et al., 2021).

The proposed model also contributes to the development of digital da'wah in educational settings. Digital da'wah is not limited to religious preaching on social media; it can also appear in educational communication that integrates Islamic values into learning practices. Aslan and Pong (2023) show that digital da'wah in Indonesia has increasingly developed through online platforms, indicating that Islamic communication is becoming more technologically mediated. In this paper, NotebookLM-based training is understood as part of this broader transformation because it enables teachers to use AI as a medium for organizing and communicating knowledge. However, this use of AI must remain guided by ethical communication. Rasiyam et al. (2023) highlight that prophetic communication in new media emphasizes responsible, ethical, and beneficial message delivery. This perspective supports the argument that AI-assisted teaching should remain human-centered and value-oriented.

The discussion also shows that teacher professional development is central to the success of AI integration in STEM learning. Zhou et al. (2023) found that professional development has a positive effect on STEM teachers' self-efficacy. This finding is relevant because teachers with stronger confidence are more likely to adopt innovative teaching strategies, including AI-supported learning. In the proposed framework, NotebookLM-based training can strengthen teachers' confidence by providing practical experience in using AI to support lesson preparation. Nevertheless, the training should avoid positioning AI as a replacement for teachers. Instead, AI should be introduced as a reflective assistant that helps teachers organize knowledge, generate alternatives, and improve instructional design.

Overall, the conceptual results suggest that NotebookLM-based training can strengthen elementary school teachers' generative AI literacy when it is designed

around three major competencies: AI literacy competence, Islamic communication competence, and STEM pedagogical competence. The framework offers a theoretical contribution by connecting generative AI literacy with Islamic communication and STEM teaching, three areas that are often discussed separately. It also offers practical implications for teacher training programs, especially in Islamic or value-based educational contexts. Since this framework has not yet been empirically tested, future studies should examine its implementation through qualitative case studies, classroom-based action research, quasi-experimental designs, or mixed-method research involving elementary school teachers.

5. Conclusion

This conceptual paper concludes that generative AI literacy is an essential competence for elementary school teachers in the contemporary educational landscape, particularly when artificial intelligence is increasingly used to support lesson planning, knowledge organization, content development, and classroom communication. The study argues that teachers should not understand generative AI merely as a technical tool, but as a pedagogical and ethical medium that requires critical evaluation, responsible use, and meaningful adaptation. In this context, NotebookLM-based training offers a relevant model for helping teachers develop the ability to use AI in a more structured, reflective, and source-based manner.

The main contribution of this paper is the proposed conceptual framework that integrates three interconnected competencies: AI literacy competence, Islamic communication competence, and STEM pedagogical competence. AI literacy competence enables teachers to understand generative AI, formulate appropriate prompts, evaluate AI-generated content, and adapt digital outputs to students' learning needs. Islamic communication competence provides an ethical foundation so that the use of AI remains guided by truthfulness, clarity, wisdom, responsibility, and benefit. STEM pedagogical competence supports teachers in designing interdisciplinary learning activities that connect science, technology, engineering, and mathematics with real-life problems in elementary education.

The integration of these three competencies shows that AI-supported teaching should not be separated from communication ethics and educational values. In Islamic educational contexts, the use of generative AI needs to be aligned with moral responsibility because teachers are not only transmitters of information, but also communicators of values. Therefore, NotebookLM-based training can help teachers use AI to organize teaching materials, generate STEM lesson ideas, evaluate content accuracy, and reflect on the ethical implications of AI use. This makes AI a supportive partner in teaching rather than a replacement for teachers' professional judgment.

This paper also contributes to the discussion of digital da'wah in educational practice. Digital da'wah should not be limited to religious messages delivered through social media, but can also be understood as the ethical communication of Islamic values through classroom learning and digital educational tools. By integrating Islamic communication with STEM teaching, teachers can design

learning activities that are intellectually meaningful and morally grounded. This approach is especially important for elementary education because students at this level are developing not only academic knowledge, but also ethical awareness, communication habits, and problem-solving skills.

As a conceptual study, this paper has limitations. The proposed NotebookLM-based training framework has not yet been empirically tested with elementary school teachers. Therefore, future research should examine its practical application through qualitative case studies, classroom-based action research, quasi-experimental studies, or mixed-method designs. Further studies may also investigate teachers' readiness, challenges, perceptions, and learning outcomes after participating in NotebookLM-based training. Overall, this paper offers a conceptual foundation for developing teacher professional development programs that connect generative AI literacy, Islamic communication ethics, and STEM pedagogical practice in elementary education.

6. References

- Abd Ghani, A., Rosli, R., Iksan, Z., Halim, L., Osman, K., Maat, S. M., Mahmud, S. N. D., Mahmud, M. S., Rambely, A. S., & Lay, A. N. (2023). STEM professional development programs for science and mathematics primary school teachers: A systematic literature review. *European Journal of Science and Mathematics Education*, 11(4), 738–753.
- Adams, C., Pente, P., Lernermeier, G., & Rockwell, G. (2023). Ethical principles for artificial intelligence in K-12 education. *Computers and Education: Artificial Intelligence*, 4, 100131.
- Aslan, A., & Pong, K. S. (2023). Understanding the trend of digital da'wah among Muslim housewives in Indonesia. *Fikroh: Jurnal Pemikiran dan Pendidikan Islam*, 16(1), 11–22.
- Busuttil, L. (2025). Constructing AI literacy: A hands-on approach for school children. *Informatics in Education*, 24(4), 761-779.
- Casal-Otero, L., Catala, A., Fernández-Morante, C., Taboada, M., Cebreiro, B., & Barro, S. (2023). AI literacy in K-12: A systematic literature review. *International Journal of STEM Education*, 10, Article 29.
- Chiu, T. K. F. (2024). The impact of generative AI on practices, policies and research direction in education: A case of ChatGPT and Midjourney. *Interactive Learning Environments*, 32(10), 6187–6203.
- Haroud, S., & Saqri, N. (2025). Generative AI in higher education: Teachers' and students' perspectives on support, replacement, and digital literacy. *Education Sciences*, 15(4), 396.
- Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., Stadler, M., Weller, J., Kuhn, J., & Kasneci, G. (2023). ChatGPT

- for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, Article 102274.
- Kronblad, C., Jonsson, A., & Pemer, F. (2024). Generative AI beyond the hype—New technologies in the face of organizing and organizations. *The Journal of Applied Behavioral Science*, 60(4), 623-630.
- Lee, J. (2026). Play with AI (PL-AI): A design-based, play-centered curriculum for fostering AI literacy in Pre-K and kindergarten. *Computers and Education: Artificial Intelligence*, 100569.
- Lo, C. K. (2023). What is the impact of ChatGPT on education? A rapid review of the literature. *Education Sciences*, 13(4), Article 410.
- Mesutoglu, C., & Akgündüz, D. (2025). Integrated STEM conceptualizations among teachers following a professional development program. *School Science and Mathematics*, 1–14.
- Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, 2, Article 100041.
- Nguyen, K. V. (2025). The use of generative AI tools in higher education: Ethical and pedagogical principles. *Journal of Academic Ethics*, 23(3), 1435-1455.
- Rasiam, R., Umiyati, U., Habibullah, H., Syahrir, D., & Said, M. (2023). Integration of new media and prophetic communication enhanced for zakah, infāq, ṣadaqah, and waqf fundraising: A case study of Baitulmaal Munzalan Indonesia. *Journal of Islamic Law*, 4(1), 28–46.
- Saleh, S. P., Cangara, H., Sabreen, S., & A. B., S. (2022). Digital da'wah transformation: Cultural and methodological change of Islamic communication in the current digital age. *International Journal of Multidisciplinary Research and Analysis*, 5(8), 2143–2151.
- Sedkaoui, S., & Benaichouba, R. (2026). Generative AI as a transformative force for innovation: a review of opportunities, applications and challenges. *European Journal of Innovation Management*, 29(3), 677-701.
- Siregar, N. C., Anggrayni, D., & Gumilar, A. (2025). Digital storytelling in STEM mathematics: Communicating islamic values through problem-based learning. *Komunika: Journal of Communication Science and Islamic Dakwah*, 9(2), 1-14.
- Siregar, N. C., Anggrayni, D., & Gumilar, A. (2025). STEM concept in islamic communication development: A conceptual paper. *Komunika: Journal of Communication Science and Islamic Dakwah*, 9(1), 73-84.
- Siregar, N. C., Rosli, R., & Siregar, R. (2025). Utilizing AI to personalize mathematics learning. *Educofa: Jurnal Pendidikan Matematika*, 2(2), 93-106.
- Siregar, N. C., Rosli, R., Warsito, W., & Gumilar, A. (2026). Impact of a STEAM-SDGs-based virtual reality mathematics learning model on students' critical thinking and creativity. *STEAM Journal For Elementary School Education*, 2(01), 63-78.

- Siregar, N. C., Siregar, R., & Herlina, H. (2025). Integrating STEM digital media on the readiness of elementary school students to face the challenges of the 2030 SDGs. *Shibyana: Jurnal Pendidikan Dasar*, 1(1).
- Storey, V. C., Yue, W. T., Zhao, J. L., & Lukyanenko, R. (2025). Generative artificial intelligence: Evolving technology, growing societal impact, and opportunities for information systems research. *Information Systems Frontiers*, 1-22.
- Trigka, M., & Dritsas, E. (2025). The evolution of generative AI: Trends and applications. *IEEE Access*.
- Wang, N., Wang, X., & Su, Y. S. (2024). Critical analysis of the technological affordances, challenges and future directions of generative AI in education: A systematic review. *Asia Pacific Journal of Education*, 44(1), 139-155.
- Zhou, X., Chen, L., & Chen, C. (2023). The effect of professional development on in-service STEM teachers' self-efficacy: A meta-analysis of experimental studies. *International Journal of STEM Education*, 10, Article 37.