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Strengthening Vocational Teachers' AI Literacy through NotebookLM Training: A Community-Based Initiative for Sustainable AI Integration in Vocational Education

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Abstract: This community service program aims to enhance vocational high school (SMK) teachers' AI literacy through NotebookLM training and to formulate practical strategies for the sustainable integration of artificial intelligence into vocational education. The program involved 35 SMK teachers and was implemented through a series of workshops, hands-on practice sessions, mentoring, and reflective discussions. Program effectiveness was evaluated using a one-group pretest-posttest design. Data were collected through validated pre-test and post-test instruments and analyzed using the Wilcoxon Signed-Rank Test and Normalized Gain (N-Gain) analysis. The results showed a statistically significant improvement in participants' understanding of NotebookLM, with mean post-test scores exceeding pre-test scores and an overall moderate N-Gain. The greatest learning gains were observed in participants' understanding and use of the Audio Overviews, Source Grounding, and Data Security features. Participants also reported increased confidence in integrating AI into instructional planning and classroom learning activities. Despite these positive outcomes, challenges related to digital infrastructure, varying levels of AI literacy, and teachers' readiness remained important considerations for wider implementation. These findings suggest that NotebookLM-based professional development can effectively enhance teachers' AI literacy while supporting the pedagogically meaningful integration of AI into vocational education. Continuous professional development, institutional support, equitable access to digital infrastructure, and collaboration with industry partners are essential to sustain AI adoption in vocational schools.

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Introduction

Artificial intelligence (AI) has developed quickly and has caused fundamental changes to many aspects of life, including education (Kamalov et al., 2023). SMK teachers face a heavy burden due to the overwhelming amount of information and the demand for innovative learning. On one hand, they must master complex and constantly evolving vocational content; on the other, they are burdened with heavy administrative work (Wetria & Supratman, 2025). Teachers need to master the dynamic vocational content and adapt to the continuous changes of curriculum regulation in the field. This translates into less time for interacting with and mentoring students.

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One suggested solution is the application of AI, especially NotebookLM, as a personal research assistant that can transform the manner in which teachers work, from simply delivering information to becoming an active learning facilitator. Google's NotebookLM is a Retrieval-Augmented Generation (RAG)-based AI tool that enables users to upload documents and interact with them through summaries, Q&A, and targeted synthesis (Reyna, 2025).

Vocational education in Indonesia, especially at the SMK level, is intended to provide students with skills in accordance with the needs of the workforce and respond to the needs of industry (Wahjusaputri et al., 2024). However, the ongoing challenge is the gap between the competencies taught in schools and the needs of the rapidly developing modern industry. Many SMKs still heavily rely on theory-based teaching methods, with less emphasis on practical and contextual learning experiences. Consequently, graduates often face challenges in meeting the requirements of the workforce, especially in industries that demand advanced technical skills and the ability to adapt to new technology (Yusro et al., 2024).

NotebookLM offers a different breakthrough than generic AI like ChatGPT. This tool does not search information from the wide internet, but only searches information from the documents uploaded by the user. This makes NotebookLM more accurate and accountable as every answer is tied to a direct reference to the original document page. Furthermore, user data is not utilized to train public models, which enhances data security (Reyna, 2025).

The Merdeka Belajar policy issued by the Ministry of Education, Culture, Research and Technology is a strategic response to the challenges of the 21st century, including the rapid development of AI. The Merdeka Curriculum provides teachers the flexibility to integrate technology into learning and encourages the development of students' digital competencies (Kemendikbudristekdikti, 2022). The integration of AI into the Merdeka Curriculum aligns with the government's pledge to prepare students with 21st-century skills, including digital literacy and computational thinking.

The understanding of technology integration in learning can be analyzed through the framework of Pedagogical Content Knowledge (PCK) (Shulman, 2013) which was then developed into Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006). Researchers in the area of AI have adapted TPACK to AI-TPACK to assess teachers' ability to integrate AI (Chiu et al., 2025; Ning et al., 2024; Setiyawan et al., 2025). The preliminary data on vocational teachers' AI self-efficacy in Banjarmasin shows that teachers have a relatively high level of confidence in using AI tools (mean score 4 on a scale of 1-5). This positive self-efficacy offers a promising basis for AI adoption, yet field observations show that teachers still experience significant difficulties in translating confidence into classroom practice. A lot of teachers lack practical experience on how to integrate AI tools into subject-specific vocational content. They do also have time constraints, given the heavy administrative workload. They have concerns about data security and information accuracy. These results support more general research findings that the maturity of digital competence at the SMK level is still low (Astuti et al., 2021) and that professional development for vocational teachers is needed to successfully use AI technologies (Daengs et al., 2024; Rais et al., 2025). Structured practice-based training, such as the proposed NotebookLM program in this community service initiative, is essential to bridge the gap between teachers' AI self-efficacy and their practical competence in AI-integrated vocational education. Based on this situation, this community service program aims to strengthen SMK teachers' AI literacy through NotebookLM training and to formulate practical strategies for sustainable AI integration in vocational education.

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Method

This community service activity applies a quantitative data analysis approach based on pre-test and post-test to determine the effectiveness of NotebookLM utilization training for SMK teachers. The present community service activity used a one-group pretest-posttest design, with measurements taken before and after training on the same group. This design was selected to evaluate the change in teachers' understanding of NotebookLM and AI after the training (Creswell & Creswell, 2023). The training activity was carried out in several stages as illustrated in Figure 1. First, participants completed a Pre-test before the training to measure initial understanding. Second, participants took part in NotebookLM utilization training covering material on AI concepts, NotebookLM features, and usage practice. Third, participants completed the same Post-test after the training to measure the improvement in understanding.

Figure 1. Stages of Activity Implementation

The training activity was carried out in several stages: 1. Participants completed a Pre-test before the training to measure initial understanding. 2. Participants took part in NotebookLM utilization training covering material on AI concepts, NotebookLM features, and usage practice. 3. Participants completed the same Post-test after the training to measure the improvement in understanding. The instrument consisted of 15 multiple-choice questions with different weights and a total score of 100. Two items did not fit during Rasch validation and were removed to reduce the total weight to 87. All scores were normalized to a 100-point scale by the formula:

$$\text{Normalized Score} = \frac{\text{Raw Score}}{87} x100 \quad (1)$$

Data were collected through a validated 15-item multiple-choice questionnaire using Rasch model analysis with 13 fit items within the acceptable MNSQ tolerance range of 0.5–1.5 (Aryadoust et al., 2021; Bond et al., 2021). The instrument showed acceptable reliability with Cronbach's alpha (KR-20) of 0.66, which falls in the moderate range of internal consistency, but still acceptable for exploratory research with a small sample size (Nunnally & Bernstein, 1994; Taber, 2018). The item reliability was 0.68, which is an acceptable reliability close to the recommended standard of 0.70.

The sample size was less than 50, and the Shapiro-Wilk Test was used to test for normality. The test is used to know if the data follow a normal distribution, which dictates the statistical test used (Field, 2024). One set of data was not normally distributed, so a non-parametric Wilcoxon Signed-Rank Test was used to determine if there was a significant difference between the pre-test and post-test scores (Sheskin, 2020). N-Gain was calculated to measure training effectiveness using the Hake (1999) formula:

$$\text{N} - \text{Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}} \quad (2)$$

Each measured aspect was analyzed item-wise to determine the improvements in understanding by comparing the percentage of correct answers on the pre-test and post-test. NotebookLM utilization training was conducted for a duration of 35 minutes and a one-day training approach was used. The training was designed to be as effective as possible in the limited time by using interactive lecture methods, live demonstrations and guided practice. The training material was delivered through a PowerPoint presentation covering six main topics: introduction to AI in education, introduction to NotebookLM and its advantages,

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NotebookLM features (including Audio Overviews, Source Grounding, Slide Outlines, Study Guide, and Briefing Doc), practical steps for using NotebookLM, ethics and data security, and case studies of implementation in vocational learning. During the practice session, facilitators accompanied participants to ensure that each participant could operate NotebookLM on their own. Training materials and step-by-step guides were distributed to help the participants to better understand the training content after the training.

Result and Discussion

Table 1. Respondent Characteristics

Characteristic	Category	Frequency	Percentage
Gender	Female	27	77.1%
	Male	8	22.9%
Age	22-30 years	17	48.6%
	31-40 years	9	25.7%
	41-50 years	7	20.0%
	51-58 years	2	5.7%
SMK Status	Public SMK	17	48.6%
	Private SMK	18	51.4%
Employment Status	PNS (Civil Servant)	9	25.7%
	PPPK (Government Employee with Work Agreement)	7	20.0%
	Permanent Teacher	7	20.0%
	Honorary/Contract Teacher	12	34.3%

Based on Table 1, participants consisted of 35 SMK teachers, predominantly female (77.1%), with ages ranging from 22 to 58 years. The majority of participants were from private SMKs (51.4%) and held various employment statuses, with the largest group being honorary/contract teachers (34.3%). This diverse profile reflects the actual demographic composition of vocational teachers in Indonesia (Kemendikbudristekdikti, 2024). The predominance of younger teachers (48.6% aged 22-30 years) is noteworthy, as millennial and Gen Z teachers tend to demonstrate higher technological literacy and faster adaptation to AI tools, though this also implies that senior teachers may require differentiated mentoring approaches (Chiu et al., 2025). The training was conducted using interactive lecture methods, live demonstrations, and guided practice to maximize learning effectiveness within the limited time. Documentation of the training activities is presented in Figure 2.

Figure 2. Documentation of Workshop Activities

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Before conducting comparative analysis, a normality test was first performed using the Shapiro-Wilk Test.

Table 2. N-Gain Interpretation Criteria

Statistic	Pre-test	Post-test	N-Gain	Category
Mean	72.41	81.14	0.32	Moderate
Standard Deviation	20.67	18.95	-	-
Highest Score	100	100	-	-
Lowest Score	25	30	-	-

N-Gain Criteria: High ($g > 0.7$); Moderate ($0.3 \leq g \leq 0.7$); Low ($g < 0.3$)
Source: Hake (1999)

Based on Table 2, normality test results show that pre-test data is normally distributed with a significance value of 0.070 (> 0.05), and post-test data is not normally distributed with a significance value of 0.000 (≤ 0.05). One set of data did not satisfy the normality assumption. Hence, the analysis proceeded with the non-parametric Wilcoxon Signed-Rank Test.

Table 3. Statistical Test Results

Statistical Test	Variable	Statistic	df	Sig.	Description
Normality (Shapiro-Wilk)	Pre-test	0.943	35	0.070	Normal
	Post-test	0.858	35	0.000	Not Normal
Wilcoxon	Z	-2.402	-	0.016	Significant
Effect Size	r	-0.42	-	-	Moderate-Large

The Wilcoxon Signed-Rank Test results show a significant difference between the pre-test and post-test scores ($Z = -2.402$, $p = 0.016$) with an effect size of:

$$r = \frac{Z}{\sqrt{N}} = \frac{-2{,}402}{\sqrt{32}} = -0{,}42 \quad (3)$$

Excluding 3 participants with perfect pre-test scores, which falls into the moderate–large category according to Gaeta & Brydges (2020). The average score increased from 72.41 on the pre-test to 81.14 on the post-test, an increase of 8.73 points. The post-test standard deviation (18.95) was smaller than the pre-test (20.67), indicating that the distribution of participant scores became more homogeneous after the training.

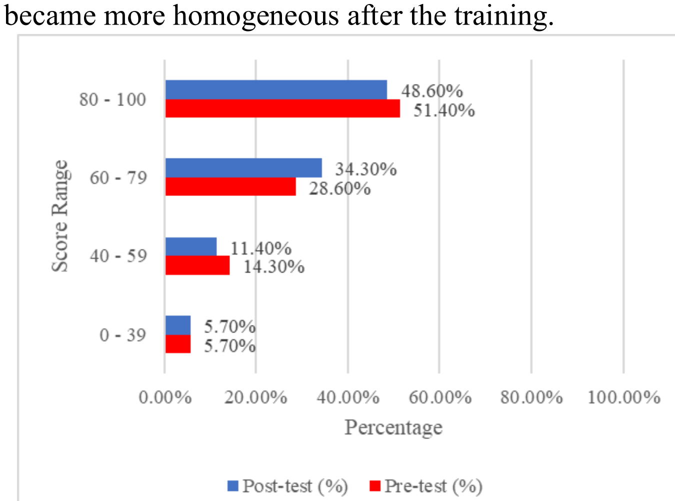

Figure 3. Frequency Distribution of Pre-test and Post-test Scores

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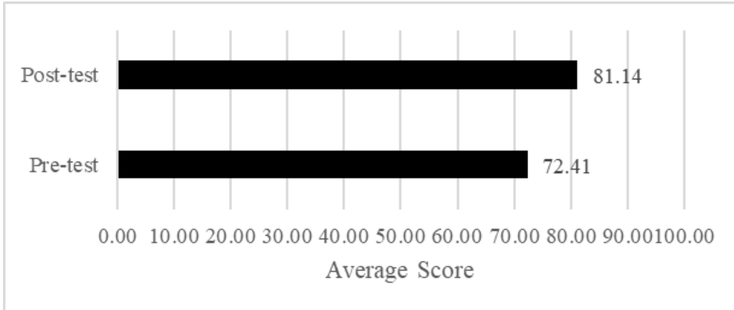

Figure 4. Average Pre-test and Post-test Scores

Figure 3 shows that although the percentage of participants in the 80-100 category decreased, the average score increased by 8.73 points due to the movement of participants from the 40-59 and 60-79 categories to higher categories. The training seems to have worked in terms of moving participants from the low-moderate to the moderate-high category. However, the increase in the very high category was not very large. The effectiveness of the training was measured by performing an N-Gain calculation. The following is the result of the N-Gain calculation:

$$\mathrm{N-Gain} = \frac{81{,}14 - 72{,}41}{100 - 72{,}41} = \frac{8{,}73}{27{,}59} = 0{,}32 \qquad (4)$$

Based on the N-Gain calculation, a value of 0.32 falls into the moderate category, meaning that NotebookLM utilization training was fairly effective in improving teachers' understanding, but still requires further mentoring to reach the high category.

Table 4. Percentage of Correct Answers per Item

No.	Topic	Pre-test (%)	Post-test (%)	Improvement (%)
1	Basic AI Understanding	85.3	94.3	+9.0
2	How NotebookLM Works	76.5	94.3	+17.8
3	Document Summarization	70.6	88.6	+18.0
4	Audio Overviews	38.2	74.3	+36.1
5	Source Grounding	50.0	77.1	+27.1
6	Slide Outlines	64.7	80.0	+15.3
7	Data Security	58.8	88.6	+29.8
8	Benefits of NotebookLM	76.5	82.9	+6.4
9	How to Upload a Module	61.8	74.3	+12.5
10	Study Guide Feature	52.9	77.1	+24.2
11	Google Drive Integration	79.4	85.7	+6.3
12	Role of the Teacher	82.4	88.6	+6.2
13	Academic Integrity	67.6	82.9	+15.3

The largest increase in understanding, according to Table 4, was in the question about Audio Overviews, followed by Data Security and Source Grounding. This shows that there was a significant improvement in understanding of practical features of NotebookLM that were not widely known to participants prior to the community service activity. The smallest increase was in the questions about the Role of the Teacher, Google Drive Integration and Benefits of NotebookLM. This means that the participants had a fairly good knowledge of these aspects before the training, so the improvement was not very large.

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Discussion

1) Training Effectiveness and the Influence of Duration

Results of Wilcoxon Signed-Rank Test showed a significant difference between pre-test and post-test scores, showing that the use of NotebookLM training was statistically effective in improving the understanding of SMK teachers. The average N-Gain score increase is moderate, showing that short training is effective to build initial awareness, but not yet sufficient for proficiency. This finding is consistent with Çelik & Dost (2025) who found that professional development of teachers in using AI needs to be a sustained approach and not a one-time training session. During the training, it was noticed that participants need more time to understand the interface, explore features, design learning scenarios and resolve technical issues, so more mentoring is needed.

2) Advantages of NotebookLM in Vocational Education

There are three major advantages of NotebookLM for vocational education. By grounding itself in user documents, NotebookLM reduces the risk of hallucination and enhances traceability of information sources, unlike generic AI (Reyna, 2025; Tufino, 2025). Audio Overviews allow documents to be converted into interactive audio discussions, supporting multimodal learning and learning through participation in workshops/laboratories (Kharbach, 2026). Private data security protects sensitive documents such as teaching modules and evaluation questions. The Slide Outlines, Study Guide and Briefing Doc features further solidify NotebookLM's position as a versatile tool for vocational education.

The Audio Overview feature has been particularly useful in supporting multimodal learning and Universal Design for Learning (UDL) principles (Setiyawan et al., 2025). Transforming documents into a podcast-style conversation between two virtual hosts (Dihan et al., 2025). Dihan et al. (2025) described the promise of NotebookLM in medical education, including ophthalmology, where it can increase low vision accessibility, improve patient education, and condense large amounts of medical information for trainees Wahjusaputri & Nastiti (2022). However, Reuter et al. (2025) pointed out that the use of NotebookLM in clinical practice has some important concerns, including the risk of perpetuating misinformation, compromising patient privacy, and media multitasking interfering with learning outcomes (Kemendikbudristekdikti, 2022). Together, these results suggest that while NotebookLM holds considerable educational promise, careful implementation and verification of its outputs remains crucial.

This finding is in line with some AI training studies in Indonesia that structured training improves AI literacy. Rosyanto et al. (2025) investigated SMK teachers in West Java and found that AI literacy and the teachers' instructional ability improved significantly, with the Design and Implementation phases being the most influential. Gozali & Ciftady (2025) conducted a study showing an increase in AI literacy scores that were higher than this study due to a longer training duration. NotebookLM, unlike general-purpose AI such as ChatGPT and Claude, uses a RAG approach, ensuring higher source accuracy and information reliability, which makes it especially suitable for vocational learning where accountability of information sources is essential.

3) The Reality of the Digital Infrastructure Gap in SMK

Gaps in digital infrastructure pose serious challenges for NotebookLM's implementation. Alam & Hidayah (2025) found three factors of ICT infrastructure readiness, namely software, hardware, and support, with the support factor being the most important. Habibi et al. (2023) found a significant difference in technology access between urban and suburban areas and schools in 3T (disadvantaged, frontier, and outermost) regions. The maturity level of digital competence among teachers and students of SMK is low (Astuti et al., 2021). Jatmoko et al. (2023) argues that infrastructure readiness is not sufficient, learning models and holistic teacher training are also required.

4) Scaffolding Strategy and Balance with Critical Thinking

NotebookLM can serve as dynamic scaffolding at these five levels: Basic cognitive (Briefing Doc, Slide Outlines, Study Guide) Metacognitive (Q&A, reflection, self-evaluation) Affective (Audio Overviews, non-judgmental feedback) Procedural (step-by-step guidance, problem solving, simulation) Collaborative (group work, knowledge sharing, peer feedback). The idea of dynamic scaffolding is consistent with Li & Wilson (2025), who found that AI can provide personalized, real-time adaptive support for independent learning, and Wulff et al. (2025), who demonstrated that AI has the potential to be effective scaffolding in education, especially in the stages of attention recruitment and task simplification. But how effective AI is as scaffolding depends heavily on the context in which it's used, and AI is still less effective in helping students set learning goals and make complicated decisions.

Strategies that can be used to maintain a balance with critical thinking are: teaching AI literacy and epistemic vigilance, because community service shows that interaction with AI can affect students' critical thinking mechanisms and it is important to develop literacy vigilance as a new direction for literacy in the AI era; applying think-pair-share with AI, which has been shown to significantly improve students' problem-solving skills and motivation; integrating cognitive conflict through contrastive analysis to encourage students to face cognitive challenges; focusing on HOTS (analysis, evaluation, synthesis, creation) given that AI has been shown to increase the number and diversity of higher-order thinking skills used by students; involving students in prompt engineering because this skill is important for optimizing interaction with AI while also developing critical thinking and AI literacy; creating an AI contract/ethical guideline to teach students to distinguish when AI functions as learning scaffolding versus when a task requires authentic intellectual engagement; and developing students' metacognitive skills so they can plan, monitor, evaluate, and adjust their AI usage strategies reflectively.

5) Strategies for Overcoming Infrastructure Barriers

In light of the infrastructure gap, five approaches can be proposed to address the barriers of NotebookLM implementation in SMKs with less infrastructure. First, there is a fundamental step that must be taken, that is, the priority of support for infrastructure, for example, electricity, bandwidth and stable internet networks. The investment in those aspects will be the basis for the establishment of more sophisticated ICT infrastructure. The most significant component in the infrastructure readiness is the supporting ICT infrastructure factors (electricity, bandwidth, internet) with a greater contribution than the software and hardware aspects (Alam & Hidayah, 2025). The World Bank Report (2021) further states that

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building a robust foundation of infrastructure through regulation, building codes and appropriate operating and maintenance systems is an important first step to ensure system reliability.

Second, there is a need for continuous practice-based training and technical support in schools to increase the digital competence of teachers in an effort to remove existing barriers and facilitate the effective use of technology in teaching. Training should be planned with the goal of building both the technical skills and the self-efficacy of teachers in the use of technology. According to the World Bank Report (2021), it is necessary to improve the quality of management and the capacity of human resources for infrastructure investment to have an optimal impact on the performance of the system. Anwar et al. (2024) proved that technology self-efficacy acts as an important mediating role between infrastructure and social support with digital technology practices.

Third, the formulation of standardized digital competence standards for vocational teachers in harmony with industry needs must be done expeditiously. The standards will be used to guide the development of training programs and to assess teacher competence. The World Bank Report (2021) suggests having clear regulations and incentives to encourage infrastructure service providers to deliver more robust and quality services.

Fourth, strategic alliances between schools, government and industry to provide access to technology, training and technical support need to be expanded and strengthened. This partnership should not be confined to the provision of hardware, but should extend to the development of digital learning content, teacher training and internship programmes for students. The World Bank Report (2021) highlights the important role of government in creating institutions and coordination mechanisms for promoting infrastructure resilience, including an all-stakeholder approach.

Fifth, a phased approach to technology implementation needs to be applied, starting from the unplugged stage (without devices), in which teachers learn AI concepts via printed modules and simulations, then a limited plugged stage using available devices on a rotating basis, up to a full plugged stage once the infrastructure is adequate. This allows schools with limited infrastructure to start their digital transformation in a gradual manner in line with the Ministry of Education's adaptive curriculum policy which accommodates schools with limited infrastructure through internet-based, device-based (plug), and device-free (unplug) implementation. Muslim & Ariyanto (2025) also agree that online literacy is a bridge between the vocational curriculum and industry competencies. Digital technology practices play a significant mediating role between infrastructure and social support in terms of technology self-efficacy (Anwar et al., 2024). This work requires a long-term commitment from all stakeholders to achieve an inclusive and equitable digital transformation.

Conclusion

From this community service, it can be concluded that the training of using NotebookLM is related to the improvement of SMK teachers' knowledge comprehension. The highest increase was observed for a practical feature (Audio Overviews), which shows that the training succeeded in bridging the technical knowledge gap of the teachers. Vocational education can benefit from using NotebookLM because of its source-grounding, Audio Overviews, and private data security. There are three key issues hampering

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implementation: gaps in the school infrastructure in 3T areas, low digital competence maturity, and uneven teacher readiness. The overarching strategy required is to build continuous AI literacy, equitable infrastructure, industry collaboration, systematic curriculum revision, and development of AI ethics policies. NotebookLM can let teachers be facilitators of learning in the 21st century with a collaborative approach.

Recommendation

The community service outcomes include several recommendations for different stakeholders.

1) Recommendations for SMK teachers: Adopt a gradual approach to uploading teaching modules into NotebookLM, actively participate in professional learning communities, and continuously develop prompt engineering skills to enhance the effective use of generative AI in teaching.
2) Recommendations for SMK school management: Provide adequate digital infrastructure, formally integrate the use of NotebookLM into the *Kurikulum Merdeka* lesson planning documents and allocate dedicated time for teachers to regularly explore and implement AI-assisted instructional practices.

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