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IPAS teachers' perspectives on digital literacy as a pedagogical foundation in the age of AI

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Abstract

This study aims to determine the perspective of digital literacy as a pedagogical foundation for IPAS teachers in the era of artificial intelligence. This study uses a qualitative approach with thematic analysis through interviews. Interviews were conducted with five IPAS vocational school teachers in the Tegal Regency. The results revealed that teachers view digital literacy as a crucial skill in utilizing digital tools and interactive digital platforms, with teachers' opinions differing significantly depending on their length of teaching experience. Three main challenges faced include limited infrastructure, student resistance, and the need for ongoing training. The findings show that teachers position AI only as a learning assistant that enriches the learning experience. The implications of the study emphasize the development of applicable digital literacy training programs and recommend collaboration among teachers through learning communities to improve teachers' pedagogical competencies.

Keywords: artificial intelligence, digital literacy, IPAS teacher, pedagogical

INTRODUCTION

The artificial intelligence (AI) revolution has transformed many sectors, including education. In the context of Natural and Social Sciences (IPAS) learning in Vocational High Schools (SMK), the use of digital technology and AI is essential to prepare students for an increasingly competitive job market (Asnawati et al., 2023). However, facing these changes is not easy, and there are challenges, especially in terms of teachers' ability to use technology effectively.

Digital literacy, is not only the ability to operate technology, but also involves critical thinking and evaluating digital information, as well as using technology to build meaningful

learning experiences (Sugiarto & Farid, 2023). Digital literacy is a basic skills in using information and communication technology devices to understand, manage, and evaluate digital information critically and responsibly according to (Fatkhomi & Widiyanto, 2025). However, in many schools, the use of digital technology in the learning process is still limited to computers and the internet, without further exploration into advanced technologies such as artificial (Chen et al., 2020). Teachers and students are increasingly using digital devices, but face difficulties that disrupt the teaching and learning process (Judijanto, 2024).

The rapid development of science and technology can influence the development of education in Indonesia. These findings demonstrate the value of integrating technology into modern classrooms and encourage educators to recognize digital literacy as a crucial skill that will drive progress, improve student academic achievement, and facilitate the development of teachers as professionals and individuals in the 21st century (Karroum & Elshaiekh, 2023). This can have a positive impact, namely helping to overcome challenges in the field of education. As Indonesia implements its 'Merdeka Belajar' curriculum and emphasizes vocational education, understanding teachers' digital pedagogical readiness is critical for the program's success. Therefore, the Natural and Social Sciences (IPAS) learning pattern needs to be updated so that the younger generation can face and overcome challenges in the future. IPAS teachers in vocational schools are expected to master digital literacy so that they can use AI in the teaching and learning process, both in preparing materials, assessment, and creating more interesting learning media (Baskara, 2025).

A teacher's pedagogical competence now focuses not only on mastery of learning materials and teaching methods, but also includes the ability to integrate digital technology and artificial intelligence into the teaching and learning process (Hayati, M. N., Arfiani, Y., & Fatkhurrohman, 2021). In this context, digital literacy is not only about technical skills, but also about how teachers should be able to select and use technology that is suitable for learning objectives and student characteristics. The results of this study (Prasetya et al., 2024) show that teachers' opinions on Artificial Intelligence differ significantly depending on how long they have been teaching.

There are quite a few challenges associated with the use of digital devices in education, including a lack of adequate training and support, limited access to technology, infrastructure issues, time constraints, cost concerns, and resistance to change (Chen et al., 2020). What is unknown is how a specific group of teachers (IPAS vocational teachers) translate broad digital literacy concepts into daily pedagogical practice in the context of rapidly evolving AI tools. Based on interviews with five teachers in Tegal Regency, key challenges include limited infrastructure, gaps in digital competencies, resistance to change, inadequate training, and superficial AI integration. The research aims to analyze teachers' perceptions and readiness regarding digital literacy in their pedagogical practices. The study explores the pedagogical competence of vocational high school (SMK) teachers, a topic that has been largely overlooked in research, particularly in the context of the AI era.

RESEARCH METHOD

This study employed a qualitative descriptive approach to analyze the perceptions and readiness of IPAS teachers regarding digital literacy and pedagogical competence in the AI era. Data were collected through semi-structured interviews with five IPAS teachers from vocational schools in Tegal Regency. This approach was chosen because it was able to explore the subjects' perspectives in depth and in a realistic manner (Mackiewicz, 2018).

The selection of five participants for this qualitative study is justified by the primary goal of achieving depth over breadth. In qualitative research, the adequacy of a sample is not determined by statistical power but by its ability to provide rich, detailed, and meaningful insights into the phenomenon under study (Pilarska, 2021). The purposive sampling technique aimed to select information-rich cases that could illuminate the research questions(Suri, 2011). Data collection continued until thematic saturation was achieved(Saunders et al., 2018); that is, interviews were conducted until additional data yielded little or no new information related to the core themes of digital literacy perspectives, pedagogical challenges, and AI integration. Analysis of the fifth interview transcript confirmed that saturation had been met, as responses began to consistently reiterate previously identified patterns and categories. This approach aligns with common practices in phenomenological and descriptive qualitative studies in educational research, where sample sizes often range from 5 to 15 participants. The interviews were conducted during June 2025, measuring five aspects: 1) digital literacy understanding; 2) use of digital technology; 3) challenges; 4) solutions; and 5) reflections, which were elaborated in ten core questions. The activities were documented with photographs and field notes during the interviews to validate the data.

The sampling technique used purposive sampling with criteria of activity/length of teaching, experience in using AI in learning, and willingness to participate in in-depth interviews. The participant profiles are shown in the following table:

Table 1. Profile of Interview Participants at Different Vocational Schools in Tegal Regency

Identity	School	Experience	Length of Service
Respondent 1	Public Vocational School Teacher	Quizziz and Chat GPT	15 years
Respondent 2	Public Vocational School Teacher	Canva and Chat GPT	12 years
Respondent 3	Public Vocational School Teacher	Canva and Youtobe	7 years
Respondent 4	Public Vocational School Teacher	Google Sheets and Instagram	9 years
Respondent 5	Private Vocational School Teacher	PhET Simulations and Google Worksheet	5 years

The data was analyzed thematically by grouping responses into main categories and analyzed thematically in stages according to the following diagram

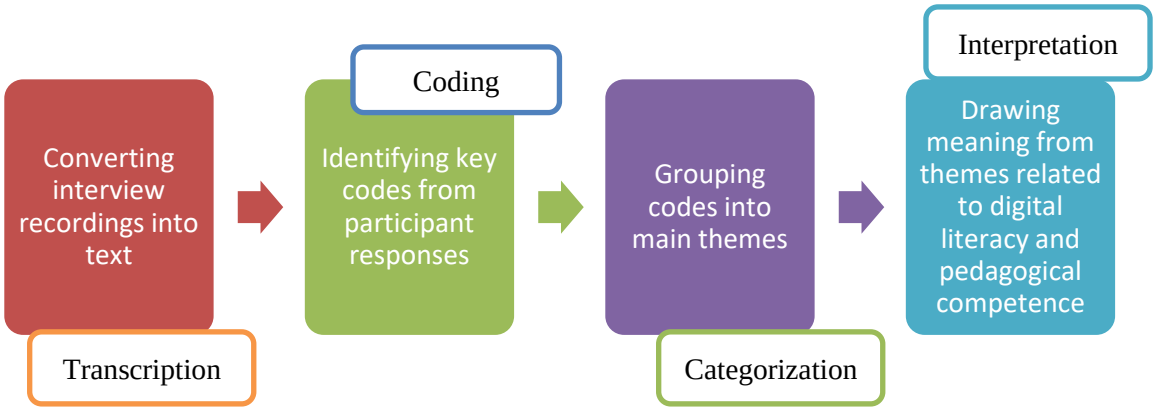

Figure 1. Summary of Thematic Analysis Stages

FINDINGS & DISCUSSION

The results of data analysis from interviews with five IPAS teachers at vocational schools in Tegal Regency revealed three key concepts, namely: 1) Digital Literacy; 2) Pedagogical Competence; 3) AI Revolution focused on four main themes. The expansion of concepts and results are presented in Figure 2 below with the support of sources using the ScopusAi application.

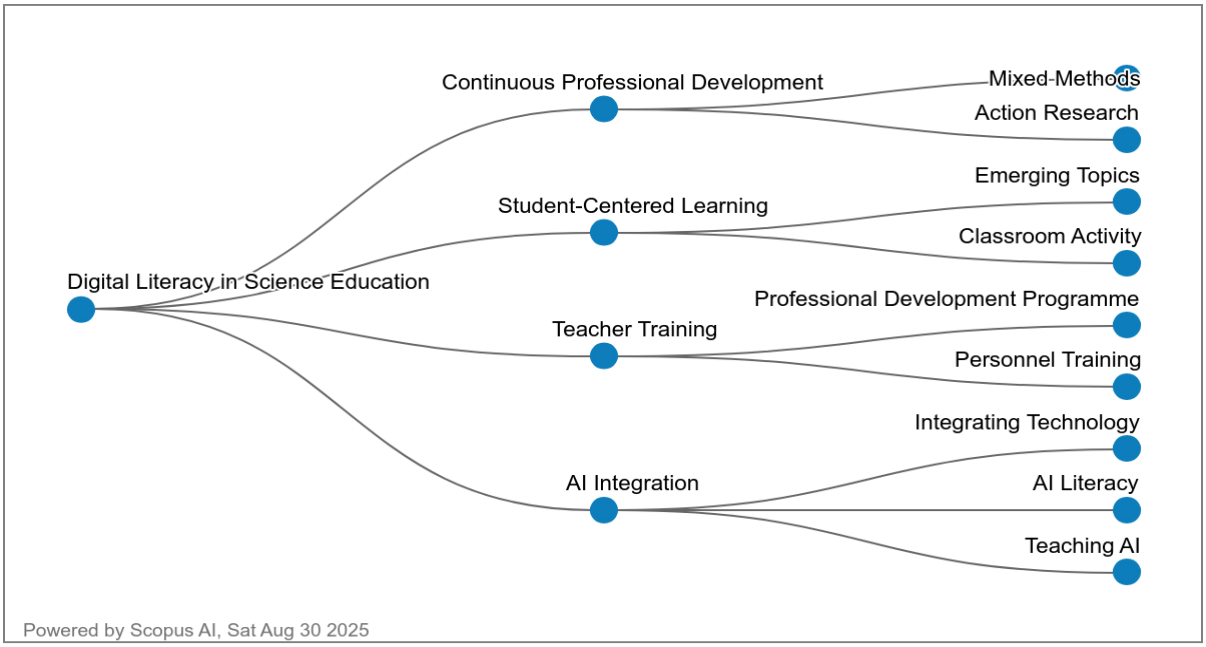

Figure 2. Concept Map of the Results

The keywords, themes, and indicators are described in 10 core questions as listed in Table 2 below.

Table 2. The Keywords, Themes, and Indicators

Keywords	Theme	Indicator	Questions
1. Digital Literacy	Teachers' perceptions of digital literacy	Teachers' understanding of digital literacy	1. How do you define digital literacy in the context of teaching IPAS in vocational schools today? 2. Do you think all teachers need to have digital literacy? Why?
2. AI Revolution	Utilization of AI and digital applications	Use of digital devices and media	3. What digital tools or applications do you use most often when teaching IPAS (e.g., ChatGPT, Canva AI, Google Lens, etc.)?
	Challenges faced	Barriers to using technology	4. What are the main challenges you face in improving your personal digital literacy as an IPAS teacher? 5. Have you ever felt pressured by the demands of keeping up with technological developments?
	Strengthening strategy	Strategies for improving digital literacy	6. In your opinion, what is the most effective solution for improving students' science process skills through the use of digital applications? 7. Have you ever participated in training or workshops on AI and digital literacy? If so, how relevant and beneficial were they? If not, what kind of training would you like to participate in?
3. Pedagogical competence		Teachers' views on the teaching profession in the age of AI	8. What is your view on the future of teachers in this digital and AI era? 9. How has your experience been in adapting IPAS material to current learning practices? 10. What is your message to young teachers in facing the challenges of education digitization?

4.1. Teachers Understanding of Digital Literacy

The indicator of teachers' understanding of digital literacy showed that all respondents described digital literacy as the ability to use digital technology critically and responsibly in the learning process. However, this definition was then combined with a greater focus on aspects related to learning.

Respondent 1: “Digital literacy for children is searching for material that they do not yet know or that is important for their studies through ChatGPT as a tool, if the information

comes from the teacher. So, digital literacy for children is learning or using existing digital applications for learning purposes at IPAS, accompanied by information or guidance from the teacher."

Respondent 5: "Digital literacy in IPAS is the ability of teachers to critically and wisely utilize AI technology to enrich and facilitate learning. This includes searching for, evaluating, using, and creating digital information for the understanding of complex concepts."

Teachers do not only view digital literacy as a technical skill, but also as a means to achieve learning objectives. This is in line with the TPACK (Technological Pedagogical Content Knowledge) framework, which combines technology, pedagogy, and content knowledge (Mishra & Koehler, 2006). In this context, digital literacy acts as a bridge between AI technology and meaningful learning (Hayes et al., 2024). By applying the concept of Technology Pedagogical Content Knowledge (TPACK), there are three important areas to consider. First, the preparation stage, where teachers must design or prepare technology-based or technology-assisted tasks that focus on exploratory activities. Second, during the implementation stage, teachers need to provide the right scaffolding to move from technical exploration to mathematical exploration. Finally, the assessment stage, where teachers can use technology to improve efficiency and accessibility (Wijaya, 2020).

4.2. Utilization of AI and Digital Tools

On the second indicator, namely **the use of AI and digital applications**, teachers agreed that the use of various digital tools to support their pedagogy was necessary. Findings showed that teachers used various digital tools such as Chat GPT, Canva, Google Workspace, PhET simulation, and Quizizz depending on their experience and access. Table 3 summarizes the applications and use of digital tools in learning as follows.

The use of digital tools demonstrates teachers' efforts to incorporate technology into their teaching methods shown like table 3.

Table 3. Use of digital tools for teachers' pedagogical needs

Aplication/ tools	Pedagogical Use	Respondent Quotes
Chat GPT	Preparation of teaching materials, questions, and modules	"Especially Canva for creating PowerPoint presentations, ChatGPT is used if there is material creation that I might have difficulty finding, or perhaps teaching modules" (R1)
Canva	Presentation media and poster design	"I usually use Canva for student learning with presentations. Besides Canva, there are various other digital platforms such as Classroom and YouTube"
PhET Simulations	Virtual lab simulation	"I often use Google Workspace (Docs, Slides, Classroom), YouTube for educational videos, PhET Interactive Simulations for virtual lab work, Canva AI to create presentations, and ChatGPT for materials that are difficult to obtain". (R5)

Google Workspace	Collaboration and task management	"I created Google Sheets for current science learning. In addition, there is also AI, social media including Instagram, which is used to post student projects, and YouTube, which is used to upload video assignments." (R2)
Quizizz	Engaging formative evaluation	"Using Quiziz when it's urgent, you can use ChatGPT or Gemini AI. Teachers don't fully master it either, but they process the answers again to give to their students" (R1)

However, the use of AI such as ChatGPT is still only at a superficial level and has not been fully utilized to train students' critical thinking skills (Zhang & Aslan, 2021). This indicates that more in-depth training in the use of AI for more complex teaching purposes is needed. In preparing the curriculum for prospective science teachers, the creation of learning content on digital platforms needs to be developed. Research findings (Rahmawati et al., 2021) indicate that digital literacy needs to be improved during science teacher training programs. This is because creating content related to producing or presenting information on various digital platforms yields lower results than accessing content, transliterating, and evaluating content.

Furthermore, the variation in technology usage among respondents can be explained in Table 4 below.

Table 4. Variations in technology use by participants

Participant	Tools used	Frequency of use
R1	Quizizz, Chat GPT	Occasionally
R2	Canva, Chat GPT	Frequently
R3	Canva, Classroom, Youtobe	Regular
R4	Google Sheets, Instagram, Youtobe	Regular
R5	Google Workspace, PhET, CanvaAI. Chat GPT	Very Often

Differences in how tools are used reveal differences in digital skills among teachers. Teachers with less work experience tend to adapt more quickly. This is consistent with research (Basilotta-Gómez-Pablos et al., 2022) that emphasizes the importance of continuous training to reduce these differences in digital skills.

A distinct gradient in the frequency of tool uptake and integration appears among participants, as Table 4 illustrates. Their claimed confidence and length of service are correlated with this variation. Respondent 1 (15 years of experience) exhibits a more restricted, sporadic pattern, whereas Respondent 5 (5 years of experience) exhibits the most varied and regular use. This initial trend points to a possible connection between the intricacy of integrating technology into education, openness to innovation, and teaching experience as shown as table 5.

Table 5. Pedagogical Integration Stage

Participant	Tools used	Frequency of use	Pedagogical Integration Stage
R1	Quizizz, Chat GPT	Occasionally	Uses assessment tools; minimal AI involvement in teaching.

R2	Canva, Chat GPT	Frequently	Visual & Generative uses technology for content creation.
R3	Canva, Classroom, Youtobe	Regular	Media usage is regular but lacks exploration.
R4	Google Sheets, Instagram, Youtobe	Regular	Focuses on teamwork and practical outcomes in education.
R5	Google Workspace, PhET, CanvaAI. Chat GPT	Very Often	Emphasizes digital fluency and thoughtful teaching design.

An illuminating lens into the participants' digital pedagogical competence the meeting point of their technical expertise and instructional strategies is provided by the inventory of digital tools (Table 3) and their different adoption trends (Table 4).

1. From Simple Utility to Innovative Pedagogy

   A utilitarian and complementary attitude to technology is shown in the employment of products (Herodotou et al., 2019) such as Quizizz (R1) largely for "urgent" formative assessment. In this case, digital tools are "add-ons" to conventional techniques, demonstrating a fundamental degree of efficiency-focused digital competency. R5, on the other hand, employs a pedagogically transformative approach through the use of Phet simulations. This tool, which demonstrates a higher-order integration of technology to accomplish certain learning objectives, was selected not for convenience but to enable experiential learning that would be unsafe or impracticable in a physical lab (Nancy et al., 2020).
2. The AI Proficiency Spectrum

   A range of vital engagement is revealed by the respondents' use of ChatGPT. Its integration lacks a clear plan for fostering students' critical thinking, even while R1 and R2 use it for material preparation a valid but passive, consumption-oriented application. This is consistent with (Saihi et al., 2025) caution against using AI superficially. Creating exercises where students evaluate AI outputs or use AI as a collaborative thought partner a nuance not yet apparent in the data would be a more advanced competency (Mikeladze et al., 2024).
3. Competence Embodied in Tool Diversity

   A teacher's digital pedagogical repertoire can be inferred from the variety of tools they employ. R5's portfolio, which includes interactive simulations and collaborative Workspace, indicates the capacity to match tool to task according to pedagogical requirement (Pande & Chandrasekharan, 2017). The TPACK framework combines technology, pedagogy, and content (Tseng et al., 2022). On the other hand, teachers may face limits in creating engaging lessons. As a result, these variations are not just related to availability or desire; rather, they are concrete examples of different developmental phases in educators' efforts to incorporate digital literacy as a fundamental pedagogical skill (Falloon, 2020). This analysis emphasizes the need for professional development to shift from tool literacy ("how to use Canva") to pedagogical design literacy ("how to use Canva to foster student collaboration and communication in science")(Feerrar, 2019).

4.3. Challenges in Integration

The next indicator is the main challenge in integrating digital literacy and teacher pedagogy. Infrastructure challenges in the form of unstable internet networks. “The challenge lies in the network or internet, which sometimes does not support us, causing lag due to the condition of our school building, which is cramped and squeezed between other buildings” (R4), as well as limited quotas and devices. “The main challenge is that students need data quotas, adequate cell phones or other equipment, or the skills to use them. Sometimes there are also students who are reluctant to accept current technology” (R1).

Pedagogical challenges, namely students tend to copy and paste from AI. “Children tend to look for the easy way out, not reading the introduction but copying and pasting directly. So, children lack digital literacy” (R1). This includes the digital competency gap between teachers. “The challenge is technological ability; each teacher is different, from newly graduated teachers to those who have been teaching for a long time. Teachers also need self-development, such as special training in the use of Canva or ChatGPT, so that they understand how to use them better. As teachers, they also need practice in applying them to their students” (R3).

Training challenges, where training on AI has never been provided. “Never, how many training courses in Yogyakarta have been attended, such as theoretical learning in the classroom, projects in any form, but in IT, it has not been provided” (R3). Additionally, there is a lack of practical, non-theoretical training. “There are many online trainings, via Zoom, provincial agencies, but rarely any offline training workshops, which are conducted offline at schools, held twice every semester” (R4).

This challenge shows that integrating digital literacy into education does not only depend on teachers' abilities, but also requires support from systems such as infrastructure, school policies, and appropriate training (Stringer et al., 2025). Generational differences in accepting technology are also a major obstacle that needs to be overcome through good cooperation (Hafner et al., 2015).

4.4. Strategies for Improvement

The fourth indicator is **strategies to improve digital skills**. Findings based on interview results show that teachers adopt various strategies to adapt to the AI revolution, such as MGMP collaboration, online/offline training, and the integration of digital-based projects.

“We are members of the school MGMP... and also participate in online training on AI.” (Respondent 2), “Every teacher meeting utilizes digital literacy.” (Respondent 4)

In fact, collaboration through MGMP communities is an effective strategy for teacher professional development, as in the study (Baskara, 2025) on the importance of developing a comprehensive framework that redefines digital literacy in the AI era by focusing on the essential competencies and pedagogical approaches needed in AI-based education.

4.5. Teachers' Views on Their Profession in the AI Era

Meanwhile, the last indicator concerns teachers' views on their profession in the AI era. Although artificial intelligence can provide a wealth of information and learning materials, the role of teachers as guides and coaches remains irreplaceable, as stated by Respondent 5. "Teachers will not be replaced, but their role will shift. From providers of information to facilitators and mentors. Teachers need to be more involved in creating personalized learning

experiences and must continue learning throughout their careers. They should teach students to use AI wisely and think critically about it. Evaluating AI tools for effectiveness and ethics is essential. (Andocilla-Oleas et al., 2025). The data indicates a correlation between teaching experience and technology integration (Farjon et al., 2019), revealing that less experienced teachers use technology more frequently. Senior teachers' resistance to technology adoption may stem from long-established effective practices, technological anxiety, and a perception that the cost of learning new tools outweighs their benefits, particularly in the absence of institutional support (Griffiths & Goddard, 2015). Address challenges with tailored professional development respecting veteran teachers' expertise and integrating AI. Beyond practical challenges, the superficial integration of AI in education carries significant risks(Karan & Angadi, 2023), particularly the erosion of critical thinking and genuine knowledge construction. When generative AI is used as a shortcut, it promotes cognitive offloading, undermining deep learning and leading to performative compliance in assignments. This dependency may also amplify biases in AI training data and perpetuate misinformation in science education (Mariam et al., 2024). Digital literacy must evolve to include critical AI literacy in vocational education, allowing users to interrogate and ethically synthesize AI-generated content(Tang et al., 2025). This study outlines essential digital literacy dimensions for IPAS teachers: (1) Tool Authenticity, utilizing real software; (2) Problem-Based Orientation, addressing real vocational challenges; and (3) Digital Workflow Competence, emphasizing collaboration and project management. Overcoming resistance to technology involves aligning professional development with industry needs to enhance relevance and employability in a digital workforce (Harrell, 2025). Continuous training is essential for teachers, focusing on using digital tools and effective teaching strategies for better learning.

CONCLUSION

Teacher competence in the age of AI involves mastering subject matter and integrating digital technology effectively. Digital literacy is crucial, requiring technical skills, critical evaluation, and ethical understanding for effective teaching in science. Effective digital literacy for IPAS teachers depends on their Technological Pedagogical Content Knowledge (TPACK), emphasizing skillful pedagogical application and meaningful learning experiences. Targeted training and curriculum design prepare teachers to effectively use AI in education.

This study has limitations, including a small sample of five participants, which limits generalizability, and a focus solely on Tegal Regency, potentially overlooking diverse Indonesian contexts. Self-reported data may introduce biases.

Practical recommendations include prioritizing hands-on AI training via MGMP and infrastructure investments to address digital divides. Schools should offer workshops on critical AI literacy for ethical use. Future research could use mixed-methods with larger samples across regions, or longitudinal studies to assess long-term AI training impacts on teachers and students.

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