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TABLE OF CONTENTS

GENERATIVE ARTIFICIAL INTELLIGENCE IN SCIENCE EDUCATION AND TEACHER TRAINING: DEVELOPMENT OF A DATA COLLECTION INSTRUMENT

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ABSTRACT

Generative Artificial Intelligence (GAI) is rapidly transforming various sectors, including science and education. In the educational sector, GAI offers opportunities, such as personalized learning and the reduction of teacher workload, alongside challenges, like balancing the advantages of GAI with students' independent problem-solving skills, but also the potential exacerbation of the digital divide. Consequently, educational stakeholders must critically assess GAI's capabilities while remaining cognizant of its potential risks. This article aims to detail the development of a data collection instrument specifically designed to qualitatively explore the perspectives of key stakeholders regarding the integration of GAI in Science Education. The developed instrument is grounded in established theoretical frameworks, notably the Intelligent Technology, Pedagogy, and Content Knowledge model (Intelligent TPACK) and the Technology Acceptance Model (TAM), which are instrumental in understanding the multifaceted dimensions of technology integration in educational settings. The instrument aims to capture: i) indicators of respondents' literacy in GAI in science education, ii) the GAI perceived ease of use in science education and GAI tools learning curve, iii) perceived usefulness of GAI tools in enhancing science education, iv) the perceived trust in GAI tools for science education content creation and factors influencing it, v) perceptions on knowledge needed for GAI integration in science education, vi) perceptions on the acceptance of GAI tools in science education, and vii) perceptions regarding GAI ethical issues in science education. In contrast to the prevailing emphasis on the technical deployment of AI in educational contexts, this study focuses on the nuanced perspectives of science education stakeholders, to inform the development of strategies for effective GAI integration in science education and science teacher education.

KEYWORDS

Artificial Intelligence in Education, Science Teacher Education, Pedagogical Practices Innovation, Qualitative Data Collection Instrument, Intelligent TPACK, TAM

1. INTRODUCTION

Artificial intelligence (AI) involves computer systems performing tasks typically requiring human intelligence, such as learning, problem-solving, decision-making, and perception. AI emulate human cognitive abilities, enabling them to execute repetitive, rule-based tasks with enhanced precision, speed, and cost-effectiveness (Dima et al. 2024). Generative Artificial Intelligence (GAI), a subset of AI, employs algorithms to generate new content, such as text, images, code generation, or music, based on training data, often performing complex tasks indistinguishably from humans (Banh and Strobel 2023). Its rapid evolution, with technologies, such as ChatGPT or DALL·E, has ushered in a transformative era in Education.

Within Education, GAI tools can potentially enhance, e.g., pedagogical design, scientific modeling, and content creation. Indeed, the integration of GAI into adaptive and personalized learning environments marks a significant shift, building upon conventional AI methods, potentially catalyzing equity and innovation within educational paradigms (Guettala et al. 2024). For example, GAI's capacity to tailor educational content to the specific requirements of individual learners has the potential to significantly diminish cognitive burden on educators, concurrently fostering enhanced learning outcomes (Bura and Myakala 2024).

Realizing GAI's transformative potential in Education demands careful attention to attitudes, readiness, and ethical issues of concern for those who are central to its implementation: teacher educators, in-service teachers, teacher trainees, and pre-service teachers. Furthermore, the limited availability of AI-learning opportunities in initial teacher education programs highlights the importance of focusing on this issue. This enables educators to make well-informed decisions about integrating GAI into their teaching practices, highlighting the need for further research to deepen understanding and best practices. These could potentially enhance the effective incorporation of AI instruction and educational outcomes (Marques 2024).

The effective integration of GAI in education demands robust conceptual models and validated instruments to gather empirical data regarding stakeholders' perspectives. One of the most recognized models is the *Technological Pedagogical Content Knowledge* (TPACK), by Mishra and Koehler (2006), that conceptualizes the need for the intersection of: a) Technological Knowledge (TK), or knowing how to use technology effectively, b) Pedagogical Knowledge (PK), or knowing teaching methods and learning theories, and c) Content Knowledge (CK), or knowing the subject matter being taught. Thus, teachers with strong TPACK can design educational experiences that explore technology to enhance student learning in specific content areas, addressing contextual nuances and diverse learner needs. Recently, Mishra, Warr, and Islam (2023) revisited the model to address the specific GAI challenge, considering these tools as active, adaptive participants rather than instruments. The *Intelligent TPACK* calls for critical teacher knowledge of AI's capabilities, limitations, and ethical implications, reframing the role of technology in education towards dynamic and responsible engagement. Another framework that is widely used in this context is the *Technology Acceptance Model* (TAM), which aims to predict how individuals accept and use new technology, focusing on the perceived usefulness and ease of use of the technology by the potential user.

Recent studies have explored these theoretical frameworks and produce data collection tools. For instance, Chiu et al. (2024) developed the *Teacher AI Competence Self-Efficacy* (TAICS) scale, grounded in Falloon's (2020) teacher digital competence framework and TPACK elements. The TAICS includes 24 items distributed in: a) AI Knowledge (AIK), b) AI Pedagogy (AIP), c) AI Assessment (AIA), d) AI Ethics (AIE), e) Human-Centered Education (HCE) and f) Professional Engagement (PEN), incorporating dimensions that reflect the ethical, pedagogical, and professional complexities introduced by AI tools. The authors reported a high reliability and strong model fit of the scale, with invariance across gender and teaching disciplines, and K–12 settings. Al-Abdullatif (2024) developed and validated a TAM-based questionnaire to examine factors influencing university teachers' adoption of GAI technologies. The tool demonstrated that AI literacy, perceived ease of use, intelligent TPACK, and perceived trust are key constructs in understanding and supporting teachers' integration of GAI in higher education. These two studies exemplify distinct but complementary approaches to understanding GAI in education. Nevertheless, both instruments can inform the design of professional development, curriculum innovations, and policy interventions aimed at fostering AI tools thoughtful analysis by educators. While valuable, these instruments primarily offer quantitative insights.

In this context, the project GAI-SciTeach aims to foster a GAI integration in teacher training that empowers and not overpowers educators and learners. The project follows a design-based research approach with iterative cycles of design, implementation, analysis, and redesign, involving active collaboration among researchers, teachers, and other stakeholders to develop a pedagogical framework tailored for the effective integration of GAI in science teacher initial education. The goal is to bridge theory and practice by generating both practical solutions and theoretical contributions. Recognizing the gap in the literature regarding tools designed for in-depth qualitative exploration of the topic, our project follows a stakeholder-driven approach to develop a qualitative data collection instrument specifically designed to explore the perspectives of researchers, teachers, future-teachers and other stakeholders regarding the integration of GAI in science education. Hence, this paper outlines the process of developing a focus group guide to collect qualitative data on stakeholders' views. The instrument addresses the research question: "What are science education stakeholders' perspectives about the integration of GAI in science education and in science teacher education?". It is structured using the PICo framework (Hosseini et al. 2024), referring to Population (stakeholders in science education, such as researchers and teacher educators, teachers, and future teachers), Intervention/phenomenon (educational integration of GAI), and Context (science teaching, science teacher training).

This article is structured to provide a comprehensive analysis of the development and design of the above proposed instrument. The next section, titled *Method for instrument development*, begins with a justification of the research question and overall approach to address it. Following, in the *Instrument description* section, each dimension of analysis is presented. The article concludes with *Final Considerations*, offering a reflection on the study, including its limitations and future work.

2. METHOD FOR INSTRUMENT DEVELOPMENT

The instrument was developed to gather qualitative data of perspectives on GAI integration via focus group (Williams and Katz 2001). The guide's development was grounded on existing quantitative instruments, the TAICS scale (Chiu et al. 2024) and an extended TAM questionnaire (Al-Abdullatif 2024), which are theoretically sound and empirically sustained tools. This strategy aims for qualitative insights, exploring the nuances and reasoning behind stakeholder perspectives on GAI integration more deeply than quantitative scales permit. The development process involved interpretation of the questionnaires' items, which were then systematically transformed into open-ended questions for the focus group. This adaptation sought to elicit authentic and non-induced viewpoints, ensure coherent yet concise discussions, and traceability to the original constructs.

To ensure the content validity of the semi-structured interview guide, expert validation was conducted involving a panel of three specialists with experience in science education and technology. These experts critically reviewed the instrument for clarity, relevance, and comprehensiveness of the questions in relation to the research objectives (Monteiro and Marques 2025). Their *feedback* informed iterative revisions, with particular attention to the alignment between the interview prompts and the conceptual framework underpinning the study. This process helped to enhance the guide's capacity to elicit rich, meaningful data, while minimizing ambiguity and potential bias.

3. INSTRUMENT DESCRIPTION

The semi-structured focus group guide is organized in three main sections, namely *Introduction*, *Development* (with the analysis dimensions), and *Closure*. according to Amado's (2014) orientations

The *Introduction* section introduces the GAI-SciTeach project and interviewer, outlines the focus group's objectives, acknowledges the value of participants' contributions, and addresses informed consent, data protection (in accordance with GDPR), and ethical procedures. Following, the core of the guide resides in the *Development* section, which explores seven key themes related to GAI integration in science education. This section utilizes a structured four-column format to ensure systematic information organization: a) Dimension/Objective, detailing the specific goal or competency area within the theme; b) Base Studies Questions, identifying the specific items from the quantitative instruments (Al-Abdullatif 2024; Chiu et al. 2024) that informed the corresponding developed qualitative questions; c) Questions, presenting the primary, open-ended questions adapted for the focus group; and d) Probing Questions, listing follow-up sub-questions designed to probe deeper into participants' initial responses, if needed. This structured approach within the *Development* section facilitates a comprehensive exploration of stakeholder perspectives while maintaining a clear link to the foundational research and ensuring depth through targeted probing. Following, each study dimension is described.

3.1 GAI Literacy

This dimension evaluates foundational competencies regarding GAI, focusing on conceptual understanding, tool recognition, productivity enhancement, and evaluative use, as depicted in Table 1. Questions probe how respondents define GAI, identify AI-powered tools, and apply GAI tools in science education settings. Items are derived from validated AI literacy constructs from both Chiu et al. (2024) and Al-Abdullatif (2024) and are supplemented with probing sub-questions that deepen inquiry into user knowledge and experience.

Table 1. Section of the instrument dedicated to the dimension of GAI Literacy

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
GAI Literacy / To collect indicators of respondents' literacy in GAI in science education	I can explain what AI is [AIK3] (Chiu et al. 2024)	1. Can you explain what Generative Artificial Intelligence is?	1a. Please define the concept as you understand it. 1b. What examples would you use to illustrate what Generative Artificial Intelligence is?
	I can distinguish whether a tool is AI-based or not. [AIK1] (Chiu et al. 2024)	2. How can people determine if new tools are based, or not, in Generative Artificial Intelligence?	2a. Can you illustrate with an example? 2b. What characteristics indicate that a tool uses Generative Artificial Intelligence?
	I can use AI applications or products to improve my work efficiency (Al-Abdullatif 2024) I can create content with AI [AIK2] (Chiu et al. 2024)	3. How can people use GAI tools in science education for greater efficiency?	3a. Illustrate, by referring to concrete tasks and objectives (in science education) that can be accomplished/achieved more efficiently through the use of GAI tools.
	I know how to choose the right AI tools to effectively complete a task. [AIK4] (Chiu et al. 2024) I can evaluate the capabilities and limitations of an AI application or product after using it for a while (Al-Abdullatif 2024)	4. How can people choose GAI tools that are adequate for carrying out a given task in science education?	

3.2 GAI Perceived Ease of Use

This dimension is dedicated to discussing GAI perceived ease of use in science education and GAI tools learning curve, as prompted by the questions in Table 2. Adapting the Technology Acceptance Model (TAM), this section investigates users' subjective ease of engaging with GAI tools. It includes queries about learning curves, clarity of use, and usability in teaching. The questions emphasize personal and vicarious experiences with learning GAI tools, exploring facilitators and barriers to skill acquisition.

Table 2. Section of the instrument dedicated to the dimension of GAI Perceived Ease of Use

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
Perceived Ease of Use of GAI tools / To assess the GAI perceived ease of use in science education and GAI tools learning curve	My interaction with GenAI tools is clear and simple (Al-Abdullatif 2024)	5. How easy or difficult is it to use IAG tools and what factors influence this?	5a. Can you illustrate with an example? 5b. What made it easy or difficult for you or for others you know?
	Learning how to use GenAI tools is easy for me (Al-Abdullatif 2024) It is easy for me to become skillful in using GenAI tools (Al-Abdullatif 2024)	6. How easy or difficult is it to learn to use GAI tools?	6a. Can you describe your experience of building skills with GAI? 6b. What kinds of support, experiences, or strategies have helped you feel more competent using them?
	I find GenAI tools easy to use for my teaching (Al-Abdullatif 2024)	7. How easy or how difficult is it to use GAI tools for science education?	7a. Can you illustrate with an example?

3.3 Perceived Usefulness

This dimension seeks to assess the functional value educators assign to GAI tools in achieving instructional goals, as depicted in Table 3. Original items explore GAI utility in enhancing teaching performance, increasing productivity, and reducing effort. Sub-questions guide respondents to articulate concrete examples.

Table 3. Section of the instrument dedicated to the dimension of GAI Perceived Usefulness

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
Perceived Usefulness / To assess the perceived usefulness of GAI tools in enhancing science education	I find GenAI tools useful for performing my teaching duties (Al-Abdullatif 2024) Using GenAI tools increases my chances of achieving high job performance (Al-Abdullatif 2024) Using GenAI tools helps me accomplish my teaching tasks effortlessly (Al-Abdullatif 2024) Using GenAI tools increases my productivity (Al-Abdullatif 2024)	8. How useful can GAI tools be in science education?	8a. Can you illustrate with an example? 8b. Can you elaborate on its usefulness for achieving higher quality results/outputs or to reduce the time needed for a certain task? 8c. How does it affect the effort required to complete a task?

3.4 GAI Perceived Trust

Trust is a critical determinant of tool adoption. This dimension of the instrument aims to address the perceived trust in GAI tools for content creation in science education and factors that influence it, as shown in Table 4. Questions investigate whether users believe GAI tools provide reliable, secure, and expectation-aligned outputs. Additional probes explore concerns around data privacy, content veracity, and psychological comfort with AI-driven recommendations.

Table 4. Section of the instrument dedicated to the dimension of GAI Perceived Trust

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
GAI Perceived Trust / To assess the perceived trust in GAI tools for content creation in science education and factors influencing it	I will use the GenAI tools if I feel that the content is trustworthy (Al-Abdullatif 2024) I will use the GenAI tools if I feel that these tools provide reliable information (Al-Abdullatif 2024) I will use the GenAI tools if I feel that these tools meet my expectations (Al-Abdullatif 2024)	9. What factors affect people's trust and will to use GAI tools for content creation?	9a. Do you trust it? In what aspects do you (not) trust it? Can you illustrate with examples? 9b. Does knowing whether something is created with GAI affect your opinion or the way you use it? Why?
	I will use the GenAI tools if I feel that these tools are secure (Al-Abdullatif 2024) I will use the GenAI tools if the data use poses no risks to teacher and learner privacy (Al-Abdullatif 2024)	10. How does users' sense of security and data privacy—or lack thereof—influence their willingness to use GAI tools?	10a. What kinds of security concerns come to mind about these tools? 10b. How do you weigh the potential benefits of GAI tools against the possible risks (e.g., privacy issues)?

3.5 Intelligent TPACK: Knowledge for GAI integration

This section assesses perceptions on knowledge that science teachers need to effectively integrate GAI tools in science teaching and learning, as shown in Table 5. This knowledge includes the ability to properly combine specific disciplinary content (Content Knowledge), pedagogical strategies (Pedagogical Knowledge) and GAI functioning (Technological Knowledge) tools, to pedagogically integrate GAI in lesson planning or adaptive instruction, for example. The questions in this section also probe the knowledge necessary for effective AI integration, such as understanding LLMs (large language models) for feedback or assessments.

Table 5. Section of the instrument dedicated to the dimension of Intelligent TPACK

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
Intelligent TPACK: Knowledge for GAI integration / To assess perceptions on knowledge needed for GAI integration in science education	I can teach lessons that appropriately combine my teaching content, GenAI tools, and teaching strategies (Al-Abdullatif 2024) I can choose an AI tool to use in my classroom that enhances what I teach, how I teach, and what students learn. [AIP1] (Chiu et al. 2024) I can choose an AI tool that enhances my teaching subject content for a lesson. [AIP2] (Chiu et al. 2024) I can teach lessons that appropriately combine my teaching subject, AI tools, and Teaching approaches. [AIP3] (Chiu et al. 2024)	11. What type of knowledge science teachers need to appropriately combine their teaching content, GAI tools, and teaching strategies to promote learning?	11a. Can you illustrate with an example? 11b. What teaching content is suited to be addressed in teaching strategies that include GAI? 11c. What GAI tools can be successfully used in science education? 11d. What teaching strategies can be explored in this context?
	In teaching my field, I know how to use different GenAI tools for adaptive and real-time feedback (Al-Abdullatif 2024) In teaching my field, I know how to use different GenAI tools for personalized learning (Al-Abdullatif 2024) I can select various GenAI tools to monitor students' learning in my teaching process (Al-Abdullatif 2024) I can use AI tool to foster assessment for learning. [AIA1] (Chiu et al. 2024) I can design an assessment approach to improve student learning in an AI-based environment (e.g., learning with ChatGPT). [AIA2] (Chiu et al. 2024) I can choose an AI tool to foster student self-assessment. [AIA4] (Chiu et al. 2024)	12. What type of knowledge science teachers need to appropriately use GAI tools to foster assessment for learning and to assess processes?	12a. E.g., what GAI tools support monitoring students' learning, to provide real-time feedback and personalized learning to students, or to foster students' self-assessment? 12b. What challenges or limitations can happen when using GAI tools this way? E.g., could it be relevant to know how to use Large Language Models (LLM) to fill in a draft of students' assessment report?
	In teaching my field, I know how to use different GenAI tools for generate quiz and assessments (Al-Abdullatif 2024)	13. What type of knowledge science teachers need to use GAI tools to evaluate students' learning?	13a. What GAI tools can work well in this area (e.g., to generate quizzes)? 13b. What challenges or limitations can happen when using GAI tools this way?

3.6 GAI Acceptance

This dimension captures perceptions on the acceptance of GAI tools in science teaching and learning, namely affective and behavioral intentions toward GAI adoption, including enthusiasm, future use plans, and advocacy, as depicted in Table 6. It details how this dimension also directs to broaden the scope beyond educators to include other stakeholders (e.g., students, parents, administrators), and examines perceived value and barriers to institutional uptake.

Table 6. Section of the instrument dedicated to the dimension of GAI Acceptance

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
GAI Acceptance / To assess perceptions on the acceptance of GAI tools in science education	I look forward to use GenAI tools in my teaching (Al-Abdullatif 2024) I intend to use GenAI tools in my future teaching (Al-Abdullatif 2024) I plan to use GenAI tools in my future teaching (Al-Abdullatif 2024) I support the adoption of GenAI tools in higher education (Al-Abdullatif 2024)	14. What are the perspectives among science teachers and students, parents and school heads about integrating GAI in teaching practice?	14a. E.g., how important is it to integrate GAI in science teaching and why? 14b. Can you illustrate with examples of situations when people revealed reservations or excitement about using these tools in science education? 14c. Should GAI adoption in science education be supported? How? Why?

3.7 GAI Ethics

This dimension focuses on perceptions regarding GAI ethical issues, as depicted in Table 7. Ethical considerations encompass responsible use, safety, well-being, and information security. Questions investigate the ethical literacy of educators and their capacity to teach these principles to students, emphasizing compliance, vigilance, and content protection.

Table 7. Section of the instrument dedicated to the dimension of GAI Ethics

Dimension / Objective	Base Studies Questions	Questions	Probing Questions
GAI Ethics / To assess perceptions regarding GAI ethical issues in science education	I can teach students ethics [AIE1] (Chiu et al. 2024) I teach students how to behave safely and responsibly when learning with AI tools. [AIE4] (Chiu et al. 2024) I can ensure my health and well-being while using AI tools. [AIE3] (Chiu et al. 2024)	15. What topics do you consider important to include when discussing GAI ethics with students and colleagues?	15a. What kind of guidelines or expectations should be set for responsible and safe GAI use, e.g., to ensure people's health and well-being while using it?
	I always comply with ethical principles when using AI applications or products. (Al-Abdullatif 2024) I am alert to privacy and information security issues when using AI applications or products. (Al-Abdullatif 2024) I can protect sensitive content from AI tools (e.g., exams, students' grades and personal data). [AIE2] (Chiu et al. 2024)	16. What kinds of privacy and information security issues are important to consider when using AI tools in science education?	16a. What steps should be taken to ensure that sensitive materials — like exams, grades, or student data — are protected when using GAI tools?

4. FINAL CONSIDERATIONS

The developed data collection instrument constitutes a rigorous, multidimensional tool for investigating GAI role in science education in qualitative studies. This theoretically anchored approach ensures construct validity, while the qualitative design, featuring open-ended and optional probing questions, supports rich, contextual data collection suitable for thematic analysis. Its comprehensive structure facilitates a nuanced understanding of how educators and other stakeholders perceive the integration of GAI in science education.

This tool aims to identify key barriers to GAI adoption, as well as explore factors that could facilitate its effective and thoughtful use. These insights could inform educational policy, professional development programs, and curriculum design, particularly in the context of GAI integration in an era of rapid technological change. Moreover, this work aims to provide a foundational tool for further qualitative research in educational technology adoption, enriching the current literature on GAI in education.

Despite the contribution this work is expected to bring to the field of teacher education and GAI integration, the instrument's limitations must be acknowledged. As a qualitative tool, it relies on participants' self-reported experiences, which may be influenced by subjective biases or social desirability. Additionally, while the instrument was developed with strong theoretical and empirical foundations, its application in different cultural or educational contexts may require further adaptation to ensure relevance and validity. Thus, although the interview guide was submitted to face validation by a panel of three experts, the authors expect to refine further the tool after a piloting study with educational stakeholders.

Overall, this research contributes to the growing body of literature on educational technology adoption, offering practical implications for science educators, policymakers, and stakeholders in the field of science teacher education. Future research will include the application of the instrument to further investigate GAI tools integration in science education, considering their relation with teaching practices and student outcomes, while exploring additional factors that may influence the widespread acceptance of GAI in education.

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REFERENCES

Al-Abdullatif, A.M., (2024). Modeling Teachers' Acceptance of Generative Artificial Intelligence Use in Higher Education: The Role of AI Literacy, Intelligent TPACK, and Perceived Trust [online]. *Education Sciences*, 14 (11), 1209. Available at: https://www.mdpi.com/2227-7102/14/11/1209.

Amado, J., (2014). *Manual de investigação qualitativa em educação* [eBook]. Imprensa da Universidade de Coimbra. Available at: https://ucdigitalis.uc.pt/pombalina/item/54493.

Banh, L. and Strobel, G., (2023). Generative artificial intelligence. *Electronic Markets*, 33 (1), 63. 10.1007/s12525-023-00680-1.

Bura, C. and Myakala, P.K., (2024). Advancing Transformative Education: Generative AI as a Catalyst for Equity and Innovation [online]. Available at: https://arxiv.org/abs/2411.15971v1 [Accessed 17 April 2025].

Chiu, T.K.F., Ahmad, Z. and Çoban, M., (2025). Development and validation of teacher artificial intelligence (AI) competence self-efficacy (TAICS) scale. *Education and Information Technologies*, 30 (5), 6667–6685. 10.1007/s10639-024-13094-z.

Dima, J. et al., (2024). The effects of artificial intelligence on human resource activities and the roles of the human resource triad: opportunities and challenges. *Frontiers in Psychology*, 15, 1360401. 10.3389/FPSYG.2024.1360401/XML/NLM.

Falloon, G., (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework [online]. *Educational Technology Research and Development*, 68 (5), 2449–2472. Available at: https://link.springer.com/article/10.1007/s11423-020-09767-4 [Accessed 28 April 2025].

Guettala, M. et al., (2024). Generative Artificial Intelligence in Education: Advancing Adaptive and Personalized Learning. *Acta Informatica Pragensia*, 13 (3), 460–489. 10.18267/j.aip.235.

Hosseini, M.-S. et al., (2024). Formulating research questions for evidence-based studies. *Journal of Medicine, Surgery, and Public Health*, 2, 100046. 10.1016/J.GLMEDI.2023.100046.

Marques, M. M., (2024). Generative artificial intelligence in teacher education: systematic literature review [online]. *EDULEARN24 Proceedings*, 1, 2503–2511. Available at: https://ria.ua.pt/handle/10773/42297 [Accessed 26 April 2025].

Mishra, P. and Koehler, M.J., (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record: The Voice of Scholarship in Education*, 108 (6), 1017–1054. 10.1111/j.1467-9620.2006.00684.x.

Mishra, P., Warr, M. and Islam, R., (2023). TPACK in the age of ChatGPT and Generative AI. *Journal of Digital Learning in Teacher Education*, 39 (4), 235–251. 10.1080/21532974.2023.2247480.

Monteiro, J. and Marques, M. M., (2025). *Guide for Expert Review of the GAI-SciTeach Focus Group Semi-Structured Interview Script* [online]. Zenodo. Available at: https://doi.org/10.5281/zenodo.15691541.

Williams, A. and Katz, L., (2001). The use of focus group methodology in education: Some theoretical and practical considerations. *International Electronic Journal for Leadership in Learning*, 5.