

MENTORING TEACHERS IN LEARNING INNOVATION MANAGEMENT USING ARTIFICIAL INTELLIGENCE LEARNING MANAGEMENT SYSTEMS AND VIRTUAL REALITY FOR SCHOOL DIGITAL TRANSFORMATION

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Abstract. School digital transformation requires teachers to manage pedagogical innovation rather than merely adopt devices. This community service program aimed to strengthen teachers' capacity at SMA Negeri 12 Ambon through integrated mentoring in artificial intelligence (AI), learning management systems (LMS), and virtual reality (VR). The program used a learning innovation management mentoring model comprising coordination, needs analysis, resource design, technical-pedagogical training, guided implementation, and evaluation. The intensive on-site phase was conducted on 1-4 September 2026, while program evidence was documented through attendance records, LMS credential lists, training materials, asset handover records, and institutional cooperation documents. Documented outputs include participation records with 50 numbered entries, the preparation of 44 teacher LMS accounts, the distribution of 50 copies of the training book *Mengajar Lebih Cerdas* [Teaching Smarter], and the transfer of four Shinecon 6.0 VR Box units with headphones. The activity was also institutionalized through cooperation and implementation agreements between Universitas Pattimura and SMA Negeri 12 Ambon. These outputs indicate that the program established access, learning resources, and institutional support needed for continued digital innovation. Follow-up should verify competency gains through prospective pre-test and post-test measures in the next mentoring cycle, LMS analytics, digital portfolios, and monitoring of reusable AI-LMS-VR learning products.

Keywords: artificial intelligence; learning management system; school digital transformation; virtual reality

Abstrak. Transformasi digital sekolah menuntut guru mampu mengelola inovasi pedagogis, bukan sekadar menggunakan perangkat teknologi. Kegiatan Pengabdian kepada Masyarakat ini bertujuan memperkuat kapasitas guru SMA Negeri 12 Ambon melalui pendampingan terpadu kecerdasan buatan (AI), Learning Management System (LMS), dan Virtual Reality (VR). Program menggunakan model pendampingan MIP-AVR yang mencakup koordinasi, analisis kebutuhan, desain sumber belajar, pelatihan teknis-pedagogis, implementasi terbimbing, serta evaluasi. Fase intensif luring dilaksanakan pada 1-4 September 2026, sedangkan bukti pelaksanaan ditelusuri melalui daftar hadir, daftar kredensial LMS, bahan pelatihan, berita acara serah terima aset, serta dokumen kerja sama. Capaian yang terdokumentasi meliputi daftar hadir yang memuat 50 peserta, penyediaan 44 akun LMS guru, distribusi 50 eksemplar buku pelatihan *Mengajar Lebih Cerdas*, serta penyerahan empat unit Shinecon 6.0 VR Box dengan headphone. Kegiatan juga diperkuat melalui Perjanjian Kerja Sama dan Implementation Agreement antara Universitas Pattimura dan SMA Negeri 12 Ambon. Capaian tersebut menunjukkan terbentuknya akses, sumber belajar, dan dukungan kelembagaan bagi keberlanjutan inovasi digital. Tindak lanjut perlu memverifikasi peningkatan kompetensi melalui pre-test dan post-test, analitik LMS, portofolio digital, dan pemantauan produk pembelajaran AI-LMS-VR.

Kata Kunci: kecerdasan buatan, learning management system, transformasi digital sekolah, virtual reality

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INTRODUCTION



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School digital transformation involves more than purchasing devices. It requires institutions to build effective, adaptive, learner-centred educational ecosystems. Teachers' digital competence, innovation management, and institutional support are essential if technology is to contribute to educational quality (Falloon, 2020; OECD, 2023; Redecker, 2017). Generative artificial intelligence (AI) offers teachers opportunities to design lessons, develop instructional materials and assessments, and provide timely feedback. Its use nevertheless requires ethical safeguards, verification, accountability, and human agency. AI should support teachers' professional work while decisions about instructional quality remain their responsibility (Ali et al., 2024; Crompton & Burke, 2023; Kasneci et al., 2023; Miao & Cukurova, 2024; Miao & Holmes, 2023; Miao et al., 2021; Zawacki-Richter et al., 2019).

Learning management systems (LMS) provide infrastructure for organizing materials, assignments, discussion forums, quizzes, rubrics, activity records, and learning analytics. Meaningful LMS use depends on planned blended learning, interaction, and teachers' ability to manage learning experiences over time (Bond et al., 2021; Hrastinski, 2019; Rasheed et al., 2020). Virtual reality (VR) enables learners to explore objects, locations, phenomena, and procedures that are difficult to present directly in classrooms. Its educational value depends on connecting immersion with learning objectives, cognitive tasks, and reflection rather than treating technological novelty as evidence of learning (Makransky & Petersen, 2021; Pellas et al., 2020; Radianti et al., 2020; Tene et al., 2024).

The program is grounded in the European Framework for the Digital Competence of Educators, which identifies 22 competences across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence (Redecker, 2017). Applied to this program, this framework links resource preparation and LMS management to assessment, learner participation, and professional collaboration. It supports treating digital transformation as a pedagogical and organizational process rather than a checklist of applications.

The teacher AI competency framework complements this foundation by addressing human-centred judgment, ethics, AI knowledge and application, pedagogy, and professional learning (Miao & Cukurova, 2024). In this program, these dimensions provide a rationale for combining prompting practice with source verification and teachers' responsibility for instructional decisions. They also justify evaluating the quality and responsible use of teacher products rather than equating access to AI tools with competence.

Immersive learning adds a further explanatory lens. The Cognitive Affective Model of Immersive Learning connects the affordances of VR with cognitive and affective processes that shape learning (Makransky & Petersen, 2021). Accordingly, demonstrations need instructional scaffolding, relevant tasks, and reflection. Together with professional learning networks (Trust et al., 2016), these perspectives explain why the mentoring model combines guided practice, shared resources, and planned follow-up. They inform the design without establishing causal effects in this descriptive implementation report.

A useful complementary framework is technological pedagogical content knowledge. Mishra and Koehler (2006) explain technology integration through the interaction of subject knowledge, pedagogy, and technological knowledge. For the present mentoring design, this means that choosing an AI application, an LMS activity, or a virtual environment should begin with a curricular problem. A teacher needs to identify what students should understand, what representations and tasks support that understanding, and which technological functions are appropriate. Familiarity with a platform is therefore necessary but insufficient for designing meaningful instruction.

Teachers' beliefs and the conditions in which they work also influence technology integration. Ertmer and Ottenbreit-Leftwich (2010) connect teacher knowledge, confidence, beliefs, and culture with technology change, while Ertmer et al. (2012) examine the relationship between beliefs and integration practices. Tondeur et al. (2017) synthesize qualitative evidence on pedagogical beliefs and technology use. These perspectives suggest that mentoring should allow teachers to explain their instructional concerns, examine usable examples, and adapt

activities to their subjects. Organizational arrangements need to support experimentation rather than assume that a single workshop changes established practice.

The preparation of teachers for technology use benefits from coherent design and opportunities to connect theory with practice. Tondeur et al. (2012) identify strategies for preparing preservice teachers to integrate technology, and Philipsen et al. (2019) review professional development for online and blended learning. Although these settings differ from an in-service community service program, they provide design considerations for linking demonstration, supported production, and reflection. Their findings are used here as conceptual guidance, with attention to the limited duration and local resources of the partner school.

Technology acceptance offers another explanation for differences in engagement. Scherer et al. (2019) synthesize the technology acceptance model in relation to teachers' adoption of digital technology. Perceived usefulness and ease of use are relevant to whether teachers see a tool as workable within their routine responsibilities. The present program therefore needs to be interpreted through both pedagogical relevance and practical access. Forty-four accounts document an opportunity to use an LMS; they cannot establish acceptance, frequency of use, or confidence without additional evidence from teachers and classroom activity.

AI integration adds questions about the reliability of generated information and the distribution of responsibility. Kasneci et al. (2023) discuss opportunities and challenges of large language models in education, while Tlili et al. (2023) consider ChatGPT within the wider educational use of chatbots. Celik (2023) extends technological pedagogical knowledge toward the ethical integration of AI tools, and Holmes et al. (2022) propose a community-wide approach to AI ethics in education. These contributions support examining accuracy, pedagogical appropriateness, and accountability together instead of judging an AI-generated product by fluency alone.

The initial needs analysis at the partner school indicated uneven capacity to integrate AI, LMS, and VR. Some teachers used digital applications for communication and presentations, but systematic technology-supported lesson design, source evaluation, and learning facilitation remained areas for development. This challenge is consistent with literature identifying individual, collegial, and organizational support as complementary conditions for teachers' professional digital competence (Instefjord & Munthe, 2017; Lindfors et al., 2021; Trust et al., 2016).

In response, Universitas Pattimura and SMA Negeri 12 Ambon implemented a mentoring program in learning innovation management using AI, LMS, and VR. The program aimed to strengthen teachers' capacity to manage instructional innovation, provide LMS access and learning resources, introduce pedagogically relevant VR use, and support continuity through school-university cooperation and follow-up activities.

METHOD

The program was conducted at SMA Negeri 12 Ambon on 1–4 September 2026 as part of Universitas Pattimura's community empowerment program. Its participatory mentoring design combined initial coordination, workshops, demonstrations, guided practice, product-development clinics, reflection, and follow-up planning. The principal participants were schoolteachers, supported by the principal and the community service team.

The mentoring model, termed MIP-AVR in the original program documentation, refers to learning innovation management using artificial intelligence, learning management systems, and virtual reality. It combines educator digital competence, teacher AI competence, blended learning, immersive learning, and professional learning networks. Its stages encompass needs assessment, conceptual input, demonstrations of tools and platforms, product-development practice, reflection, and school follow-up planning (Hrastinski, 2019; Makransky & Petersen, 2021; Miao & Cukurova, 2024; Redecker, 2017; Trust et al., 2016).

Implementation evidence was examined descriptively through document triangulation. Sources comprised attendance records, the LMS account register, the training book *Mengajar Lebih Cerdas* [Teaching Smarter], asset handover records, cooperation and implementation agreements, and photographs. Evidence was grouped into participation, digital access, learning resources, supporting equipment, and institutional sustainability. Account credentials were used to establish the number of accounts and are not reproduced in this article. These records document implementation outputs; they do not constitute measures of competency gains or learning effectiveness.

Operational Logic of the Mentoring Design

The mentoring stages can be understood as a sequence linking needs, activity, output, and follow-up evidence. Initial coordination establishes the partner's priorities and available resources. Needs assessment informs the instructional focus. Resource design translates that focus into materials and examples. Training introduces technical functions and pedagogical decisions, and guided practice allows teachers to connect them. Reflection identifies what is feasible after the intensive phase. Table 1 presents the relationship between priority needs, intended interventions, and documentary indicators; these indicators represent implementation rather than validated competence measures.

The three technology components address different points in an instructional workflow. AI can support the drafting of a lesson outline or an assessment item. A teacher then evaluates the draft for subject accuracy, curriculum alignment, level of difficulty, and appropriateness for students. An LMS can distribute the revised resource, organize submission, and provide a place for feedback. A VR activity can add an experience that students examine through guiding questions. This workflow illustrates the model's instructional logic; it should not be read as evidence that each participant completed an integrated product.

The document analysis distinguishes units that must not be treated as interchangeable. Attendance entries refer to the participation register, teacher accounts refer to access provision, books refer to distributed learning resources, and VR units refer to equipment. No denominator for completion, classroom adoption, or competency improvement can be derived by combining these counts. In particular, the difference between 50 attendance entries and 44 teacher accounts does not demonstrate dropout. The records serve different administrative purposes, and participant-level linkage would be needed to explain any relationship between them.

Prospective Assessment and Interpretation

A future evaluation cycle should connect the mentoring activities with explicit indicators before data collection begins. Desimone (2009) emphasizes the need to link features of professional development with teacher knowledge, practice, and student outcomes. Applied here, a competency measure should address the actual activities teachers are expected to perform, such as verifying an AI response, designing an LMS task, or aligning a VR experience with a learning objective. Assessment procedures, scoring criteria, timing, and participation records should be specified prospectively to support interpretable comparisons.

Pre-test and post-test comparisons would require paired observations from the same teachers, a consistent scoring scale, and transparent handling of missing responses. A future report should state the number assessed at each time point and the number contributing paired data. If the planned 25% gain is retained, the program must define whether it denotes relative improvement from baseline or percentage-point change on a bounded scale. Neither interpretation is applied to the present records because baseline and follow-up scores are not available. Reporting uncertainty and measurement limitations is necessary even when an average improvement is observed.

Product evaluation would complement tests by examining pedagogical decisions in authentic materials. An assessment rubric could distinguish subject accuracy, alignment of

objectives and activities, quality of feedback, accessibility, and responsible technology use. Two assessors could independently review a sample of products and discuss disagreements before final scoring. The planned target that 80% of products reach a good category requires an operational definition of that category and a stated denominator. This is a proposed assessment procedure for follow-up rather than an instrument already administered during the reported program.

Table 1. *Partner needs, mentoring interventions, and documented implementation indicators*

Priority Need	Mentoring Intervention	Documented Implementation Indicator
Uneven teacher digital competence	Needs assessment, integrated training, and product-development clinics	Attendance record with 50 numbered entries; training materials available.
AI use lacks consistent pedagogical direction and ethical guidance	AI-assisted planning, pedagogical prompting, assessment, verification, and ethics	Training book addresses AI-supported learning and boundaries of use.
LMS not yet used as a comprehensive learning management environment	Account creation and guidance on classes, materials, tasks, quizzes, forums, rubrics, and monitoring	Account register contains 44 teacher LMS accounts.
Limited experience with VR	VR device practice, virtual tours, 360-degree content, and immersive activity design	Four Shinecon 6.0 VR Box units with headphones handed over.
Innovation sustainability needs institutional support	Partnership, professional learning community, training of trainers, and follow-up planning	Cooperation and implementation agreements provide a basis for continued collaboration.

RESULT AND DISCUSSION

Program implementation and participation

The intensive phase on 1–4 September 2026 involved the partner school in program activities. Figure 1 documents the group session and classroom setting, including the opening, commitment building, reflection, and follow-up discussions. The attendance document contains 50 numbered entries; this count should not be interpreted as evidence that every participant attended all sessions. Participation provides a basis for teachers to learn through direct experience, discussion, and collaborative practice (Bond et al., 2021; Trust et al., 2016).



Figure 1. *Universitas Pattimura community service team and participants, and the reflection and follow-up session at SMA Negeri 12 Ambon.*

Instructional input and teacher capacity development

Figure 2 documents presentations, discussions, and instructional guidance within the mentoring activities. Teachers were introduced to AI-assisted lesson planning, pedagogical prompting, and assessment support, alongside the use of LMS as a structured learning environment. Preparing 44 teacher LMS accounts established access for subsequent practice. Pedagogical success, however, depends on the quality of activities, interaction, and feedback within digital classrooms rather than account creation alone (Bond et al., 2021; Hrastinski, 2019; Rasheed et al., 2020).

The program also provided the training book *Mengajar Lebih Cerdas: Manajemen Inovasi Pembelajaran Berbasis AI, LMS, dan Virtual Reality* [Teaching Smarter: Learning Innovation Management Using Artificial Intelligence, Learning Management Systems, and Virtual Reality]. It addresses innovation management, AI-supported learning, LMS as a pedagogical ecosystem, VR and 360-degree content, evaluation, ethics, and implementation strategies. Written resources can support continued learning, professional discussions, and internal school mentoring after the intensive phase. This approach is consistent with the need for sustained professional learning and network support in digital competence development (Instefjord & Munthe, 2017; Lindfors et al., 2021; Trust et al., 2016).



Figure 2. *Presentations, discussions, and instructional guidance during the artificial intelligence, learning management system, and virtual reality training.*

Learning management system practice and virtual reality demonstration

Figure 3 documents LMS practice in the computer laboratory and a demonstration of VR equipment. The program used simple viewing devices that could be shared among groups or used in rotation.



Figure 3. *Learning management system practice in the computer laboratory and demonstration of virtual reality equipment.*

The handover record documents four VR Box units with headphones as initial school equipment. The pedagogical rationale is to connect immersive experiences with learning objectives and reflection, the novelty of a device alone does not establish instructional effectiveness (Makransky & Petersen, 2021; Pellas et al., 2020; Radianti et al., 2020; Tene et al., 2024).

Institutional support and program sustainability

Institutional support comprised learning resources, equipment, and formal cooperation arrangements. The asset handover record dated 1 September 2026 lists 50 training books valued at IDR 5,304,000 and four VR Box units with headphones valued at IDR 3,725,568, for a total of IDR 9,029,568. The principal received the assets on behalf of SMA Negeri 12 Ambon. A cooperation agreement between the Postgraduate Program of Universitas Pattimura and the school established the partnership, while an implementation agreement specified the community service activity. These arrangements provide organizational support for continuity; they do not, by themselves, demonstrate sustained classroom use (Lindfors et al., 2021; OECD, 2023).

Table 2. *Implementation outputs documented in program records*

Component	Evidence	Quantity or status	Relevance to sustainability
Participation	Attendance record	50 numbered entries	Participant base for practice and professional learning.
LMS access	LMS account register	44 teacher accounts	Access for subsequent digital classroom development and analytics.
Learning resources	Teaching Smarter training book	50 copies	Reference for continued learning and internal mentoring.
VR equipment	Asset handover record	4 VR Box units with headphones	Equipment for rotating group practice and immersive learning design.
Partnership	Cooperation and implementation agreements	Available	Institutional basis for monitoring, replication, and continued collaboration.

Pedagogical implications and further evaluation

Competency gains cannot be quantified from the available implementation records. The original program design set targets of at least a 25% increase in competency scores, 80% of products rated as good, and a minimum of 10 active LMS classes or templates. These are planned targets, not observed results. Assessing them requires pre-test and post-test records, product-assessment rubrics, LMS analytics, and follow-up documentation. A baseline must be obtained before any subsequent intervention; a retrospective test cannot recover the missing baseline for the completed intensive phase. Monitoring should examine changes in instructional practice, including verified and accountable AI use, structured and interactive LMS activities, and VR tasks aligned with cognitive objectives. This approach reflects the emphasis on human agency, competence, governance, and impact evaluation in educational technology adoption (Miao & Cukurova, 2024; Miao & Holmes, 2023; Miao et al., 2021; OECD, 2023).

Responsible artificial intelligence use in instructional design

The provision of a training book creates a reusable reference for AI-assisted preparation. Its pedagogical value depends on whether teachers can turn guidance into defensible instructional decisions. For example, a generated explanation should be checked against reliable subject sources, and a proposed assessment item should be examined for ambiguity, factual errors, and unintended clues. Teachers need to revise outputs for their students' prior knowledge and language needs. Such review is consistent with the opportunities and risks described by Kasneci et al. (2023) and the ethical integration perspective discussed by Celik (2023).

Responsible use also requires a clear boundary between assistance and professional accountability. Teachers should be able to explain why they accept or reject a generated resource, and students should receive guidance about acceptable assistance in their own work.

Sensitive student information should not be entered into external systems without an appropriate basis and school procedures. The ethics discussion in Holmes et al. (2022) supports treating these decisions as shared institutional responsibilities. These considerations are recommended practices; the available program records do not establish that school-wide procedures were adopted or that compliance was assessed.

Pedagogical use of learning management systems

An LMS account is a prerequisite for access, while a functioning learning environment requires organized teaching activity. A useful follow-up audit would examine whether a class contains a clear learning sequence, accessible materials, meaningful tasks, and teacher feedback. Rasheed et al. (2020) review challenges in the online component of blended learning, including difficulties that cannot be resolved by platform provision alone. Hrastinski (2019) clarifies the varied meanings of blended learning. These perspectives support assessing how face-to-face and online activities relate rather than counting uploaded files as an adequate indicator of pedagogical integration.

The target of at least 10 active classes or templates should be separated into two indicators. A template demonstrates a prepared design; an active class involves use by intended learners. Future analytics could examine access over a defined period, assignment completion, feedback records, and discussion activity, interpreted alongside teacher explanations. Activity counts remain imperfect measures: frequent logins do not necessarily indicate deep learning, and low access may reflect connectivity constraints. The program should therefore use analytics to identify questions for follow-up rather than rank teachers solely through automated counts.

Virtual reality scaffolding and equitable access

The four shared VR viewing units provide an entry point for experimentation, but their instructional affordances need to be distinguished from those of advanced immersive systems studied in the literature. Radianti et al. (2020) synthesize design elements in higher education VR applications, and Hamilton et al. (2021) review quantitative learning outcomes and experimental designs. Differences in devices, interaction, tasks, and participants limit direct transfer to this school program. A low-cost viewer and 360-degree content cannot be assumed to produce the same experience or effect as a fully interactive immersive environment.

Research also cautions against treating presence or enjoyment as sufficient evidence of learning. Makransky et al. (2019) report that adding immersive VR to a science laboratory simulation increased presence but reduced learning in their study, while Parong and Mayer (2018) examine learning science in immersive VR. These findings support careful task design and cognitive scaffolding. Before viewing, students could receive a small set of observation questions; afterwards, they could explain a phenomenon, compare representations, or justify a conclusion. The proposed sequence should be tested locally rather than described as an outcome already achieved.

Shared equipment introduces practical access decisions that matter for sustainability. Teachers could organize small-group rotation with equivalent non-headset activities so that participation does not depend on every student owning a compatible device. Instructions should identify the intended learning task and allow students to stop if they experience discomfort. An accessible alternative could use the same visual content on a standard screen with corresponding questions. These are recommended design options for later implementation, not documented accommodations from the intensive phase. Their effectiveness would need to be examined through participation records and learner feedback.

Professional collaboration and institutional continuity

Institutional agreements and written resources establish a basis for continued collaboration, but a sustainable professional learning process also needs recurring opportunities to examine practice. Vescio et al. (2008) review research on professional learning communities and their relationship to teaching practice and student learning. Trust et al. (2016) examine professional learning networks, while Philipsen et al. (2019) identify considerations for online and blended teacher development. A school community of practice could use these

perspectives to organize product sharing, classroom reflection, and peer feedback around specific curricular problems rather than technology demonstrations alone.

A feasible follow-up arrangement would assign responsibility for account support, equipment scheduling, and pedagogical mentoring, with dates for reviewing teacher products. The university team could provide feedback on a selected set of materials while school-based teacher facilitators support colleagues in routine use. Such an arrangement remains a proposed continuation of the partnership. Its implementation should be evidenced by meeting records, reviewed products, and documented classroom activity. Formal agreements are valuable because they enable coordination, but evidence of continuity requires repeated activity after the initial handover and training sessions.

Limitations and transferability

The principal limitation is that the report relies on administrative and visual implementation evidence rather than direct measures of changes in teacher competence. It has no comparison group, paired competency dataset, systematic classroom observation, or student learning dataset. Consequently, the analysis cannot attribute instructional improvement to the mentoring model. It also does not establish how many accounts were used after training, how often resources were consulted, or how equipment was integrated into lessons. These questions identify the next evaluation priorities instead of weakening the value of documenting initial implementation conditions.

Transferability should be considered at the level of design logic rather than assumed impact. Other schools may adapt the combination of needs analysis, teacher practice, reusable resources, and institutional cooperation, but staffing, connectivity, access to devices, and curricular priorities can alter feasibility. Findings from higher education and preservice teacher studies inform this discussion without eliminating those contextual differences. A subsequent multi-school evaluation could examine whether the same implementation components support sustained teacher practice under different conditions. Such an evaluation would require common indicators and transparent contextual descriptions before comparisons are made.

CONCLUSION

The mentoring program at SMA Negeri 12 Ambon established documented foundations for learning innovation through attendance records with 50 numbered entries, 44 teacher LMS accounts, 50 training books, four VR Box units with headphones, and formal institutional cooperation. These outputs demonstrate implementation and resource provision, but do not establish increased teacher competence or improved student learning. Follow-up should assess teacher products and classroom practices, audit the target of at least 10 active LMS classes, develop contextual VR and microlearning content, and organize a professional learning community and training of trainers for core teachers. Pre-test and post-test measurement should be built prospectively into the next mentoring cycle. Continued monitoring should examine ethical AI use, the pedagogical quality of LMS activities, and the relevance of VR experiences to learning objectives.

REFERENCES

- Ali, O., Murray, P. A., Momin, M., Dwivedi, Y. K., & Malik, T. (2024). The effects of artificial intelligence applications in educational settings: Challenges and strategies. *Technological Forecasting and Social Change*, 199, 123076. <https://doi.org/10.1016/j.techfore.2023.123076>
- Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2021). Emergency remote teaching in higher education: Mapping the first global online semester. *International Journal of Educational Technology in Higher Education*, 18(1), 50. <https://doi.org/10.1186/s41239-021-00282-x>

- Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, 138, 107468. <https://doi.org/10.1016/j.chb.2022.107468>
- Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education*, 20(1), 22. <https://doi.org/10.1186/s41239-023-00392-8>
- Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181-199. <https://doi.org/10.3102/0013189X08331140>
- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, 42(3), 255-284. <https://doi.org/10.1080/15391523.2010.10782551>
- Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, 59(2), 423-435. <https://doi.org/10.1016/j.compedu.2012.02.001>
- Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 68(5), 2449-2472. <https://doi.org/10.1007/s11423-020-09767-4>
- Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education*, 8(1), 1-32. <https://doi.org/10.1007/s40692-020-00169-2>
- Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Buckingham Shum, S., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, 32(3), 504-526. <https://doi.org/10.1007/s40593-021-00239-1>
- Hrastinski, S. (2019). What do we mean by blended learning? *TechTrends*, 63(5), 564-569. <https://doi.org/10.1007/s11528-019-00375-5>
- Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education*, 67, 37-45. <https://doi.org/10.1016/j.tate.2017.05.016>
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, 102274. <https://doi.org/10.1016/j.lindif.2023.102274>
- Lindfors, M., Pettersson, F., & Olofsson, A. D. (2021). Conditions for professional digital competence: The teacher educators' view. *Education Inquiry*, 12(4), 390-409. <https://doi.org/10.1080/20004508.2021.1890936>
- Makransky, G., & Petersen, G. B. (2021). The Cognitive Affective Model of Immersive Learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review*, 33(3), 937-958. <https://doi.org/10.1007/s10648-020-09586-2>
- Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, 60, 225-236. <https://doi.org/10.1016/j.learninstruc.2017.12.007>
- Miao, F., & Cukurova, M. (2024). *AI competency framework for teachers*. UNESCO. <https://doi.org/10.54675/ZJTE2084>
- Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research*. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000386693>
- Miao, F., Holmes, W., Huang, R., & Zhang, H. (2021). *AI and education: Guidance for policy-makers*. UNESCO. <https://doi.org/10.54675/PCSP7350>

- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- OECD. (2023). *OECD Digital Education Outlook 2023: Towards an effective digital education ecosystem*. OECD Publishing. <https://doi.org/10.1787/b12e15ef-en>
- Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality. *Journal of Educational Psychology*, 110(6), 785-797. <https://doi.org/10.1037/edu0000241>
- Pellas, N., Dengel, A., & Christopoulos, A. (2020). A scoping review of immersive virtual reality in STEM education. *IEEE Transactions on Learning Technologies*, 13(4), 748-761. <https://doi.org/10.1109/TLT.2020.3019405>
- Philipsen, B., Tondeur, J., Pareja Roblin, N., Vanslambrouck, S., & Zhu, C. (2019). Improving teacher professional development for online and blended learning: A systematic meta-aggregative review. *Educational Technology Research and Development*, 67(5), 1145-1174. <https://doi.org/10.1007/s11423-019-09645-8>
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>
- Rasheed, R. A., Kamsin, A., & Abdullah, N. A. (2020). Challenges in the online component of blended learning: A systematic review. *Computers & Education*, 144, 103701. <https://doi.org/10.1016/j.compedu.2019.103701>
- Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union. <https://doi.org/10.2760/159770>
- Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, 128, 13-35. <https://doi.org/10.1016/j.compedu.2018.09.009>
- Tene, T., Marcatoma Tixi, J. A., Palacios Robalino, M. L., Mendoza Salazar, M. J., Vacacela Gomez, C., & Bellucci, S. (2024). Integrating immersive technologies with STEM education: A systematic review. *Frontiers in Education*, 9, 1410163. <https://doi.org/10.3389/educ.2024.1410163>
- Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learning Environments*, 10(1), 15. <https://doi.org/10.1186/s40561-023-00237-x>
- Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development*, 65(3), 555-575. <https://doi.org/10.1007/s11423-016-9481-2>
- Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education*, 59(1), 134-144. <https://doi.org/10.1016/j.compedu.2011.10.009>
- Trust, T., Krutka, D. G., & Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computers & Education*, 102, 15-34. <https://doi.org/10.1016/j.compedu.2016.06.007>
- Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education*, 24(1), 80-91. <https://doi.org/10.1016/j.tate.2007.01.004>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39. <https://doi.org/10.1186/s41239-019-0171-0>