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Building AI Literacy for Sustainable Teacher Education

Abstract

This article highlights the significance of AI Literacy for promoting sustainable teacher education in an AI-driven world. Given the rapid progress of AI, a crucial aspect of organisational development for teacher education institutions involves fostering AI Literacy among teaching staff, and enabling them to use and teach AI ethically and responsibly. We underscore the necessity for teacher education institutions to create opportunities for developing AI Literacy as a fundamental goal for sustainable development. Further, we explore recommendations for sustainable organisational and professional development as well as future research directions.

Keywords

AI literacy, sustainable educational institutions, teacher education, higher education development, teacher educators' competences

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1 Introduction

Global societal transformation and exponential technological advancements precipitate new demands and challenges for education, the teaching profession and teacher education institutions (GAŠEVIĆ et al., 2023; LILIENTHAL & SCHROEDER, 2020). These raise fundamental questions about the core competences needed for active and responsible participation in future societies – questions that need to be approached from a perspective of sustainable educational development. Higher education institutions carry a particular responsibility towards promoting, developing and maintaining strategies for sustainable development in society (RUESCH SCHWEIZER, 2019). With this responsibility, teacher education institutions play a pivotal role in meeting the consistently changing demands for education as they seek to enable future generations for responsible societal participation (LILIENTHAL & SCHROEDER, 2020). As AI increasingly permeates all societal sectors (LAUPICHLER et al., 2023), teacher education institutions need to adapt their practices to the changing requirements of the educational and vocational domains to ensure sustainable teaching and research (STROBEL & WELPE, 2017). An equitable uptake of AI in education (AIEd) in times of unprecedented change, however, requires a sound understanding of AI technologies across educators, researchers, and learners alike (CETINDAMAR et al., 2022). Empowering all individuals to acquire competences for sustainable and responsible use of AI across all life-dimensions is thus a core sustainable development goal of teacher education institutions.

One way of approaching this objective is to establish structures to foster AI Literacy – a concept that encompasses a set of competences that enable individuals to understand, use, monitor, and critically reflect AI (LONG & MAGERKO, 2020). While this concept requires further empirical research (LONG & MAGERKO, 2020; ZHOU et al., 2020), scholars from various disciplines maintain that promoting AI Literacy in education will help prepare employees for constructive collaboration with AI (FLORIDI et al., 2018), educate critically thinking citizens to understand technologies with a relevant impact on their lives (NG et al., 2021), support educators to better comprehend the challenges and opportunities surrounding the appropriate and responsible integration of AI in education (LONG & MAGERKO, 2020), and enable higher education management to mitigate the AI-transformation effectively (GAŠEVIĆ et al., 2023).

This contribution discusses sustainable teacher education from the perspective of the AI-related competences required to design sustainable and effective teaching practices in an increasingly AI-mediated world. We argue that the promotion of AI Literacy for (teacher) educators constitutes a core objective of sustainable higher education development.

2 Towards Sustainable Teacher Education in the Age of AI

Sustainable development aims to meet the needs of the present without compromising the ability of future generations to meet theirs (RUESCH SCHWEIZER, 2019). With AI's potential disruptive power, its impact on society is predicted to be of extraordinary scale, largely determining who humans can become, what they will be able to achieve, and how they will interact with one another and the environment (FLORIDI et al., 2018). Each of these dimensions can entail appropriate use of AI and create opportunities, underuse of AI and create opportunity costs, and over- or misuse and create risks (FLORIDI et al., 2018). As central drivers for sustainable development across all societal domains, teacher education institutions bear the responsibility to address both the opportunities and risks posed by the AI-transformation (RUESCH SCHWEIZER, 2019). This includes, among others, educating learners on leveraging AI for creating opportunities rather than incurring opportunity costs (KANDLHOFER et al., 2016; NG et al., 2021). Sustainable teacher education thus needs educators to develop competences to convey the necessary AI-skills to learners – competences that reach far beyond *mere knowledge*. In other words, (teacher) educators *and* learners need to become AI-literate (KANDLHOFER et al., 2016; NG et al., 2021). The nature of this goal is core to the main objectives of sustainable development and is interwoven with and operationalized in the UNESCO sustainable development goals (UNESCO, 2017). Goal number four outlines that sustainable educational institutions "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all [… and] contribute to a progressive, healthy society" (UNESCO, 2017). In the era of AI, a progressive and thriving society effectively harnesses the benefits of AI while responsibly addressing its risks and challenges (FLORIDI et al., 2018). This ability is essential for safeguarding

equitable access to technical, vocational, and higher education (target 4.3) and for increasing the number of individuals equipped with relevant skills, including technical and vocational skills, to achieve financial success through employment and entrepreneurship (target 4.4). Acquiring AI Literacy is prerequisite for effectively addressing the challenges and opportunities presented by AI and for progressing towards these sustainable educational development goals (KANDLHOFER, et al., 2016; NG et al., 2021).

3 Connecting the Dots: AI Literacy

The AI Literacy concept originates in AI research from various disciplines. While the publications on AI Literacy have increased significantly since the early 2020s (CROMPTON & BURKE, 2023; LAUPICHLER et al., 2022, 2023; NG et al., 2021), empirical research is still scarce (LAUPICHLER et al., 2022). In addition, an abundance of existing conceptualizations of AI Literacy (e.g., KANDLHOFER et al., 2016; LONG & MAGERKO, 2020) inhibit a universally valid definition (LAUPICHLER et al., 2023).

With the increasing appropriation of AI in education, AI is considered a powerful instrument to facilitate opportunities for instructional design, technological development, and educational innovation and research (OUYANG & JIAO, 2021). Emerging AI systems that can learn and make predictions from classifying and correlating big data (e.g., protocols like GPT-4 integrated in chatbots like ChatGPT, Bard, Copilot etc.) have led to a new paradigm in AI (WILLIAMSON & EYNON, 2020). Generative AI can now create images or videos from text, and large language models are able to produce reasonably sophisticated text with only short prompts (GAŠEVIĆ et al., 2023; MCKNIGHT, 2021). The public release of ChatGPT by OpenAI in November 2022 marked a profound paradigm shift in both the public awareness and education's perception of AI. This shift has raised enticing possibilities for future human-AI collaboration in creative and knowledge work but has also heightened concerns about bias, ethics, fairness, and accuracy (GAŠEVIĆ et al., 2023). Such a significant transformation influences the (popular) understanding of AI and AI Literacy, thereby rendering the demands for a clear definition increasingly prevalent.

Emerging from and extending technological literacies (e.g., digital, computational, scientific, or data literacy), AI Literacy encompasses the competences that enable "individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace" (LONG & MAGERKO, 2020, p. 2). Long and Magerko's AI Literacy framework (2020) conceptualizes AI Literacy to encompass seventeen competences spanning from the ability to distinguish between technological artefacts that do and do not use AI, identify AI's strength and weaknesses, recognize and describe examples of how computers reason and make decisions, understand that data requires critical interpretation, or to understand that AI-agents are programmable. Fifteen design considerations for learning centred on AI Literacy complement the framework. These include, for example, relaying and fostering the understanding of AI-related concepts such as explainability, contextualising data, promoting transparency, fostering critical thinking, or acknowledging preconceptions. The concept's transdisciplinary nature highlights the need to know significantly more than merely how to use AI applications. Instead, individuals need to be familiar with the underlying concepts and ethical concerns of AI to succeed in their professional lives and become responsible citizens (NG et al., 2021).

AI Literacy describes the skills and knowledge of non-experts. Non-AI-experts are individuals who have not received formal training in AI, are not AI-developers, and use AI applications in their personal or professional lives. As the majority of today's digital applications are at least partially based on AI, all individuals who interact with sophisticated digital applications may be considered non-AI-experts (LAUPICHLER et al., 2023). Building on LONG and MAGERKO's (2020) framework, we situate AI Literacy within the domain of teacher education institutions and target teacher educators as (non-AI-expert) learners, carriers, and conveyors of AI Literacy.

4 AI Literacy and Teacher Education

Education's chief performance mandate is to prepare people to sustainably navigate complex futures characterized by unprecedented societal change, technological advancements, and active engagement and collaboration with AI (GAŠEVIĆ et al., 2023). This quest poses significant challenges for educators, researchers and policy makers alike (GAŠEVIĆ et al., 2023). As teachers and teacher educators bridge schools' and universities' AI policies and learners' needs, they play a critical role in the successful implementation of AI in education and meeting this performance mandate (WANG et al., 2023). In order to empower learners to become AI-ready (cf. WANG et al., 2023), educational institutions need to secure sustainable learner experience improvement through the increased implementation of AI in their practices (GAŠEVIĆ et al., 2023). Developing (teacher) educators' AI Literacy, i.e. knowing and understanding AI, its application to pedagogy and teaching, and the implications thereof – informed by the AI-Literacy skills future generations will require (c.f. TOURETZKY et al., 2019) – is thus pivotal and can be conceptualized as a new, additional step in educators' professionalization process (CHIU et al., 2023). Indeed, educators need to develop AI Literacy expertise so they can facilitate learning, scaffold task design, and design appropriate assessment practices in an AI-mediated educational environment (NG et al., 2021). Prerequisite is knowing and using suitable AI technologies (e.g., adaptive learning systems, intelligent learning environments, data analytics, automated scoring or feedback systems etc.) to understand students' learning needs and progress, to promote personalized learning and the development of evaluative judgement, and to foster students' AI Literacy including critical and constructive collaboration with AI (NG et al., 2021). However, as developments in technology and AI progress and educational systems only slowly adapt to systemic change, concerns about the growing influence and challenges regarding sustainably appropriating AI in education proliferate (GAŠEVIĆ et al., 2023) and current research and teaching practices struggle to keep up. Educators differ significantly regarding their understanding and application of AI in their work (WANG et al., 2023). Many lack knowledge about AI technologies, how they function, and how to interact with them productively. They face challenges implementing AI effectively in their teaching and understanding its pedagogical implications. Unawareness or misconceptions about AI can lead to inflated expectations, inappropriate reliance on (EDUCAUSE, 2022), and ineffective collaboration with AI (CETINDAMAR et

al., 2022; LONG & MAGERKO, 2020). This knowledge gap may significantly stall educational and societal progress (WANG et al., 2023).

Similarly, research on AI Literacy is in its infancy and largely heterogeneous (LAUPICHLER et al., 2022). One dominant strand focuses on interventions to teach and assess AI Literacy and evaluate AI Literacy programs. For instance, KANDLHOFER et al. (2016) developed a 4-stage-model for fostering AI Literacy across all educational levels. Other examples are LAUPICHLER et al.'s (2023) study to develop an AI Literacy assessment scale for non-AI-experts, HORNBERGER et al.'s (2023) work to develop a multiple-choice test to assess AI Literacy in higher education, or KONG et al.'s (2021) and WANG et al.'s (2022) research studies to develop AI Literacy tests to evaluate AI Literacy courses. While promising results regarding the effectiveness of AI Literacy programs were found by KONG et al. (2023), the limited existing research on AI-Literacy-course effectiveness yet requires caution when drawing respective conclusions. Another strand encompasses conceptual work on AI Literacy. For instance, CETINDAMAR et al. (2022) identified four sets of capabilities related to AI Literacy that contribute to sustainable organisational practices. WANG et al. (2023) studied teacher agency by empirically investigating their AI readiness (i.e., state of preparedness to use AI in education) and found that high AI readiness positively predicted AI-enhanced educational innovation and job satisfaction. These types of publications are crucial for understanding AI Literacy more in-depth.

However, research on AI Literacy in higher (and teacher) education needs further efforts (LAUPICHLER et al., 2022). Empirical evidence on how to define, foster and assess AI Literacy is scarce, and research on AI Literacy as a sustainable development goal of teacher education institutions is, to the best of our knowledge, absent. Yet, empirical evidence points to the promising potential of fostering AI Literacy to promote innovative, future-oriented, and sustainable teaching practice and professional performance that benefit educators' personal and professional development and professionalization, the development of their learners, and the sustainable development of their organizations.

5 Building AI Literacy

To ensure that AI Literacy development initiatives are sustainable and suitable for the educational context, appropriate structures based on solid conceptual foundations are essential (NG et al., 2021). However, as the AI Literacy concept is only young, suitable frameworks are scarce (LAUPICHLER et al., 2022). The TPACK-model (Technological Pedagogical Content Knowledge), for instance, falls short to address knowledge of the digital cultural and AI transformation (THYSSEN et al., 2023). DPaCK (Digitality-Related Pedagogical Content Knowledge), its recent extension, compensates for this lack by interconnecting social, societal, and ethical considerations with Content Knowledge (CK) and Pedagogical Knowledge (PK) (THYSSEN et al., 2023). With its connectivity to social and cultural sustainability, we propose DPaCK as an initial conceptual foundation for AI Literacy development initiatives in teacher education institutions. Adapted to the AIEd context, Digitality-related Knowledge (DK) encompasses knowledge about AI-tools, their principles, algorithms, and functions, as well as AI's transformative capabilities and ethical and societal implications. The nexus of Digitality-related and Pedagogical Knowledge (DPK) involves understanding the affordances and challenges of applying AI to pedagogy and the implications thereof. Digitality-related and Content-related Knowledge (DCK) includes knowledge of appropriate AI-tool-use in relation to specific subjects as well as respective implications (e.g., safeguarding that AI-tools enhance, not dilute, content depth, accessibility, and learning success). Finally, Digitality-related Pedagogical and Content-related Knowledge (DPaCK) constructively integrates all facets in a model for AI-Literacy development in AIEd. Like TPACK, DPaCK is a meta-model that primarily serves as a theoretical framework. Thus, while its holistic ambition provides a promising conceptual foundation for AI Literacy development, empirical analyses are needed to determine its fit and whether DPaCK sufficiently addresses the complexities of AI.

6 AI Literacy Development in Practice

Governments and higher education institutions are recognizing the importance of AI Literacy at varying rates and are approaching development initiatives at varying rates and are launching development initiatives in various domains. At an educational policy level, for instance, China's AI Innovation Action Plan (2018)[2] or Austria's Artificial Intelligence Mission (AIM AT 2030)[3] underline the countries' commitments to harnessing and constructively using the potentials of AI in (higher) education. At the organizational level, most higher education institutions engage with AI (cf. CHAN, 2023). In this context, building educators' and learners' AI Literacy can be achieved through professional development initiatives (top-down, providing guidance and professionalization support for the faculty) or collaborative efforts with learners (bottom-up, exploring constructive AI practices, assessing the appropriateness of AI in teaching and learning, and understanding the potentials and limitations of AI applications, and doing so collaboratively and as AI novices, cf. MCKNIGHT, 2021; NG et al., 2021). At the time of writing this article, however, the focus yet predominantly lies on ethical concerns and challenges related to performance assessment (e.g., data protection, copyright). One example that combines both top-down and bottom-up approaches constitutes the St. Gallen University of Teacher Education's recently developed AI policy. As a sustainable organizational development initiative, it aims to gradually incorporate AI into the institution and its study programs. Strand 1 entails the continuous assessment of all stakeholders' needs regarding AI as well as the potentials and challenges experienced respectively. Strand 2 focuses on providing faculty with professional AI-Literacy-development opportunities to progressively integrate AI into the curriculum. The 3rd strand seeks to safeguard fair, valid, and reliable educational assessment in an evolving AI-permeated environment and provides support to teaching staff regarding aspects such as academic integrity, ethics, and legal implications of AI use. Strand 4 addresses AI-use for BA and MA theses by collaboratively developing strategies to ensure continuous adaptation to fluctuating circumstances while maintaining high quality standards. At the organizational level, the final strand 5 encompasses a collaborative

2 AI Innovation Action Plan for Institutions of Higher Education: https://cset.georgetown.edu/publication/ai-innovation-action-plan-for-institutions-of-higher-education/

3 AIM AT 2030: https://www.ki-strategie.at/

approach to AI adoption, compliance with guidelines, knowledge transfer and faculty training to ensure all members become AI-literate and can, in turn, impart these skills to their (future) students. Other institutional examples, mostly of top-down and transdisciplinary nature, constitute the Massachusetts Institute of Technology's open-access Daily-AI workshop[4], which serves both internal training and continuing education purposes. A similar initiative was recently launched by the University of Helsinki. Their service encompasses a series of free online courses on topics such as the nature of AI, its capabilities and limitations, and how to create AI teaching methods.[5] Aside from these exemplars, however, not many approaches by tertiary education institutions that address AI Literacy are publicly accessible yet. As development in this field is likely to progress rapidly, establishing best practice principles is going to be increasingly possible as soon as more educational institutions start to share their approaches and findings with the wider community.

7 Further Research

Research desiderata regarding AI Literacy as a sustainable organisational development goal of teacher education institutions are abundant. There is a need for a clear definition of AI Literacy (LAUPICHLER et al., 2022) and respective operationalizations to enable the development of appropriate teaching methods and objective, valid and reliable assessment instruments (LAUPICHLER et al., 2022). Researching the concept also requires identifying and empirically validating its facets, and identifying AI Literacy requirements of stakeholders who are impacted by AIEd (GAŠEVIĆ et al., 2023). Such endeavours are intertwined with the need for operationalizing AI Literacy in frameworks to guide and support (teacher) educators in designing AI-integrated teaching arrangements with appropriate, situated pedagogies and assessment criteria (NG et al., 2021). In addition, AI Literacy pedagogy research needs to identify practices that effectively harness the weaknesses of AI technologies as opportunities for promoting higher-order learning and the acquisition of AI Liter-

4 Created by the MIT Media Lab Personal Robots Group and the MIT STEP Lab: https://raise.mit.edu/daily/index.html

5 Elements of AI: https://www.elementsofai.com/

acy, and to what extent these practices contribute to learning success (GAŠEVIĆ et al., 2023). Further research also needs to be conducted on assessing AI Literacy (cf. LAUPICHLER et al., 2023), which may encompass developing and validating AI Literacy assessment scales and instruments for general and specific-purpose use (e.g., assessing language teacher educators' AI Literacy).

Additionally, research should inquire (teacher) educators' and learners' perceptions of and attitudes towards AI, and their relationship with the behaviour and development of AI Literacy facets. Building an accurate understanding of non-AI-experts' preconceptions about AI is central for deducting best practice principles for teaching AI Literacy to the respective audience in context (LONG & MAGERKO, 2020). Investigations of the role and significance of AI Literacy within organizational development and sustainable teacher education institutions are required, for instance, regarding the effectiveness and perception of AI Literacy professional development initiatives, and their long-term impact on organizational development, sustainability, and innovation. Finally, more research is needed on ethics, bias, and fairness and accountability of AIEd, educators' AI Literacy development, and institutional and policy guideline development to increase the responsiveness of educational systems to rapid changes driven by AI (GAŠEVIĆ et al., 2023).

8 Conclusion

In this article we outlined how teacher education institutions may respond to the growing influence of AIEd and put forward an argument to foster AI Literacy among teacher educators as a sustainable organisational development goal. We identified AI Literacy as a core competence that needs to be acquired by all individuals, especially teacher educators, and taught to future generations. By incorporating the AI Literacy concept into the DPaCK model, we proposed DPaCK as a framework that may serve as a preliminary basis for designing AI-Literacy development initiatives. Whether an AI-enhanced education, or education in an AI-enhanced world, will succeed, will largely depend on educators' readiness for and appropriate understanding, use, and teaching of AI (WANG et al., 2023). In this respect, we strongly argue for teacher educators to become informed stakeholders about the future of education and vocation in an AI-permeated world (CETINDAMAR et al., 2022). In-

stitutions creating opportunities to develop AI Literacy is imperative to meet these demands (CETINDAMAR et al., 2022). Given AI's broad impact on all aspects of teacher education, cross-committee collaboration is necessary to successfully integrate AI into the broader institutional context and adapt to changing circumstances continually. As the current constellation of technological advancements indicates, the short-term future will be one of continued and fast-paced progress (GAŠEVIĆ et al., 2023). As AI proceeds, teacher educators can only continue to sustainably engage with future AI design if they develop AI Literacy – a prerequisite for remaining (or becoming) an active part of their AI-enabled future selves and thus contribute to building an inclusive and equitable society (CETINDAMAR et al., 2022).

9 References

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