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Mapping the Field

A Comparative Analysis of the Research on AI Literacy in Higher, Continuing, and Further Education Since 2022

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Abstract

With the rapid progression of Generative AI and its transformative force in multimodal understanding, reasoning and (language) generation (Liu et al. 2025), cultivating competencies, skills and abilities related to AI, summarised under the umbrella term AI literacy, appears to be of paramount importance. Therefore, the following mapping review aims to cumulate, analyse, and compare the current state of research on AI literacy in higher, continuing, and further education, concerning the definitions of the construct, the theoretical underpinnings of the field, and didactic approaches to foster AI literacy. A total of 4,013 records were screened on titles and abstracts, followed by the screening of 278 full texts. Subsequently, 142 articles were deemed eligible for data extraction and analysis. Papers were included if they were published in English or German between 2022 and May 2025, were peer-reviewed journal articles or conference papers, and focused primarily on AI literacy and higher, continuing, and/or further education. The results point to the need to clearly define the terminology used, to research AI literacy in continuing and further education, and explore synergies between educational contexts, innovative didactic approaches, and learning designs.

Kartografie des Forschungsfeldes. Eine vergleichende Analyse der Forschung zu AI Literacy in der Hochschul- und beruflichen Fort- und Weiterbildung seit 2022

Zusammenfassung

Angesichts der Fortschritte generativer Künstlicher Intelligenz in den Bereichen multimodales Verstehen, Argumentieren und der Generierung von Artefakten (vgl. Liu et al. 2025) erlangt die Förderung von KI-Kompetenzen, die unter dem Oberbegriff AI Literacy zusammengefasst werden, eine immer entscheidendere Bedeutung. Demgemäß zielt das vorliegende Mapping Review darauf ab, den Stand der Forschung zu AI Literacy in der Hochschul-, Fort- und Weiterbildung in Hinblick auf verwendete Definitionen, theoretische Grundlagen

und didaktische Ansätze abzubilden, zu analysieren und zu vergleichen. Insgesamt wurden 4.013 Artikel auf Basis ihres Titels und Abstracts und anschliessend 278 Beiträge auf Basis des Volltexts hinsichtlich ihrer inhaltlichen Passung überprüft. Die kriteriengeleitete Auswahl eines Artikels erfolgte, wenn er zwischen 2022 und Mai 2025 in englischer oder deutscher Sprache publiziert wurde, es sich um einen Zeitschriftenartikel (peer-reviewed) oder Konferenzbeitrag handelte und ein klarer Fokus auf AI Literacy im Rahmen der Hochschul-, Fort- und/oder Weiterbildung festgestellt werden konnte. Folglich wurden 142 Artikel in die Datenauswertung und -analyse einbezogen. Die Ergebnisse weisen auf Weiterentwicklungspotenziale sowohl in der Forschung als auch in der Bildungspraxis hin. Diese betreffen etwa die klare Definition verwendeter Terminologie, Studien zu AI Literacy im Rahmen von Fort- und Weiterbildungsmaßnahmen sowie den Ausbau innovativer didaktischer Ansätze und Synergien zwischen Bildungskontexten.

1. Introduction

Educational fields are progressively and continuously impacted by Artificial Intelligence (AI), leading, for instance, to discussions around AI usage in teaching and learning (e.g. Wannemacher, Bosse, Lübcke, et al. 2025), to questions of assessment (e.g. Lintner 2024; Reinhold and Händel 2025), ethics or policies (e.g. Stracke et al. 2025). Drawing on Holmes et al. (2025), this vast discourse and research field can be clustered in *AI in Education* (AIED; addressing the usage of AI tools in education), *AI literacy* (AIL; AI-related education aiming at the development of proficiency in the field) and *AI and Education* (AI&ED; multiple agents' development and employments of policies, frameworks and strategies addressing AIL and AIED).

AIED as such is a constantly evolving field of study and practice that draws on multiple disciplines to rationalise and optimise teaching methods, learning activities, and evaluative measures (Ouyang and Jiao 2021; K. Wang et al. 2025). Given the fast progression of Generative AI (GenAI), its pervasiveness and transformative force in multi-modal understanding, reasoning and (text and artefact) generation (Liu et al. 2025), the need for AIL to bridge the gap between technological advances and user preparedness is growing (Pinski and Benlian 2024).

Due to the constructs' fluid and adaptable nature, the public and scientific understandings of AIL differ (e.g. Dadhich and Bhaumik 2023). However, a widely cited definition of AIL by Long and Magerko (2020) defines the latter as the ability to understand, critically examine and use AI in various contexts. Moreover, Wolters et al. (2024) add that «the development of AI literacy is understood as a long-term educational process» (Wolters et al. 2024, 6891). While practitioners and researchers do not lack definitions of AIL (c.f. chapter 4.2), the attempts and effects of didactic approaches to foster AI literacy seem underexplored, especially in profession-related adult education formats (Laupichler et al. 2022a; Wolters et al. 2024), further summarised under the umbrella term *continuing and*

further education (CFE). Moreover, while research has been focusing on AIED for over 60 years (Bond et al. 2024), its incorporation into non-STEM fields of education has evolved fairly recently (Hossain, Alwreikat, et al. 2025; James and Maldonado-Molina 2025). This leads to an enforced call for the integration of AIL in curricula, which is answered by exploratory research (e.g. Abid et al. 2024; Sengewald and Tremmel 2024), AI&ED policies and strategies (e.g. Budde and Tobor 2025; Miao et al. 2021), and the development of measuring instruments (e.g. Hornberger et al. 2023). Nevertheless, research on AI literacy needed in various professions and workplaces is still in its infancy. Studies by Fleischmann et al. (2024), Alamäki et al. (2024), or Marinaş et al. (2024) emphasise the importance of preparing adult learners and students for an AI-entangled job market by enhancing skills and competencies, including the ability to distinguish the chances and risks of AI technologies, to use AI in a responsible manner and competencies in human agency and authenticity. These and further competencies and skills seem imperative, as the advent of GenAI and further AI technologies foster new possibilities, opportunities, and challenges for workplaces across various disciplines (Fleischmann et al. 2024; Jaiswal et al. 2025; Prasad Agrawal 2024). Therefore, the objective of this study is to synthesise and compare definitions of the construct, as well as frameworks and didactic approaches to AIL in higher education (HE), in contrast to continuing and further education (CFE). This overview and comparison aim to contribute to the development of AIL curricula, didactics, and learning designs that support the development of competencies and skills urgently required across various workplaces (Toker Gokce et al. 2025; Salhab 2024).

Compared to prior studies, this study introduces two innovations to the field. First, while previous research mainly investigated a single educational sector at a time or did not clearly distinguish between higher, continuing, and further education (e.g., Wolters et al. 2024; Wyk 2024), the present study aims to compare HE and CFE. Understanding the distinct or similar approaches to foster and research AIL in bespoke contexts seems crucial, given that learners exhibit diverse profiles. Likewise, the boundaries between the fields appear to be malleable: students transition into employment, where they engage in profession-specific further training and education, and conversely, employees have and use the opportunities to enrol in HE programmes (Bartholomäus et al. 2025; Powell and Solga 2010). The attempt of investigating both educational fields can also be justified from a lifelong learning perspective and the increasing blurring of boundaries between educational phases (Hazelkorn and Locke 2023; London 2021). From a media education and learning design perspective, digital technologies – and, in this context, increasingly AI systems – influence and further develop learning and educational contexts that span entire biographies and do not stop at institutional borders (Mayrberger 2019). HE and CFE are no longer sequential, isolated phases, but increasingly intertwined and reciprocal learning spaces (Dollhausen 2013). Therefore, a comparative approach could facilitate the identification of connections, disruptions, and transfer potential within the context of this educational continuity.

Second, to the best of our knowledge, no review thus far (e. g. Laupichler et al. 2022a; Wolters et al. 2024; Pinski and Benlian 2024) has synthesised didactic approaches to promote AIL in comparison between bespoke educational contexts, including the associated teaching and learning objectives and activities. As AI technologies become integral to modern industries and professions, HE and CFE must adapt to this changing landscape by developing and fostering skills, competencies, and abilities aligned with AI-enhanced work environments, as illustrated by Jaiswal et al. (2025) and Marinaş et al. (2024). Therefore, adopting a didactic lens to this comparative analysis appears essential. So, in order to expand the current state of research in this field, this study addresses the following research questions:

RQ1: Which definitions, frameworks and models are referenced in the research on AI literacy in higher, continuing, and further education?

RQ2: Which teaching and learning objectives, didactic approaches, and methods are drawn upon to foster AI literacy in both educational sectors?

2. Literature Review

2.1 *Artificial Intelligence in Education (AIED) and Education about AI*

In times of misinformation, the reinforcement of biases, dangerous stereotypes and inequalities through AI, a need for a critical stance towards AI technology and the economic and political interests associated with it seems mandatory for responsible citizens (Bender 2025; Gengler et al. 2025; Holmes et al. 2025). Meanwhile, multifaceted human proficiency in understanding and applying AI interweaves rising parts of human life and is simultaneously demanded by them (Bender 2025; Touileb et al. 2023; Siemens 2025). This ranges from healthcare (e. g. Kimiafar et al. 2023; Subaveerapandiyan et al. 2024) to politics and economics (e. g. European Commission 2025; World Economic Forum 2022), workplaces (e. g. Cetindamar et al. 2024; World Economic Forum 2025), and education (e. g. Holmes et al. 2025), among others. These entanglements and omnipresence of AI underpin the growing understanding of AIL as a key set of competencies, skills, and abilities for our times.

However, while recent increases in publications and discourses indicate that scientific endeavours surrounding AIL and AIED are among the most discussed contemporary topics, the interdisciplinary research field has a long-standing history dating back decades (Bond et al. 2024; Doroudi 2023). While earlier AIED studies focused on areas such as intelligent tutoring systems or adaptive learning environments, the current emphasis is on creating new synergies and use cases (e. g. Wannemacher, Bosse, and Lübcke 2025). This trend is partly driven by the rapid advancements in machine learning, GenAI, and AI usage in educational institutions (Bond et al. 2024; Wannemacher et al. 2025).

Moreover, possible advantages and difficulties of adopting AI in HE and other educational fields appear to be well-explored already. For instance, research indicates that AI can enhance personal learning and assessment by being highly adaptable and contributing to time savings for educators (e. g. Alotaibi and Alshehri 2023; Bond et al. 2024; Reinhold and Händel 2025). Simultaneously, various challenges in implementing AI in education emerge, and serious concerns are raised by educators and learners (e. g. Andocilla-Oleas et al. 2025; Cao et al. 2025). For instance, Bond et al. (2024) demonstrate that the most common concerns regarding the use of AI in HE relate to ethics, ahead of obstacles in embedding AI into the curriculum, establishing AI infrastructures, and securing sufficient funding. Another issue concerns the reliability of AI-generated output, or as Schröder et al. (2025, 1) summarise, Large Language Models are «useful but fundamentally unreliable tools that need to be validated against human responses for every new application».

These findings emphasise the importance of further exploring AI in educational processes, both in terms of addressing didactic issues as well as investigating questions regarding learning about AI as an educational subject, as Köstler (2023, 2) outlines.

2.2 Foundations of AI Literacy and Related Literature

Although the concept of AI has been studied since the 1950s (McCarthy et al. 2006; Turing 1950), the term *AI literacy* was, to our knowledge, first used in a blog post about the Japanese economy (Konishi 2015) and later adopted by Burgsteiner et al. (2016), introducing a curriculum for teaching AI topics in secondary schools. One of the earlier definitions of AI literacy, published by Kandlhofer et al. (2016), grasps the former as fundamental capabilities in using AI technologies in everyday activities and work-related settings. Related to other established technological literacies such as *data literacy* or *media literacy* (Pinski and Benlian 2024), Long and Magerko (2020, 2) later define AIL «as a set of competencies that enables individuals to evaluate AI technologies critically; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace». This concept broadens the range of suggested technological literacies by focusing on the comprehension, application, and evaluation of AI as a disruptive technology (Hobeika et al. 2024; Laupichler et al. 2022a). Based on this broad definition, Long and Magerko (2020) propose a conceptual framework of AIL, comprising 16 AI-related competencies, that range from recognising AI to understanding the steps of machine learning, to proficiency in AI ethics. Ng et al. (2021b) then expand this framework and cluster AI-related skills and competencies in the four dimensions *Know and Understand AI*, *Use and Apply AI*, *Evaluate and Create AI* as well as *AI Ethics*, referring to Bloom's Taxonomy (Bloom, 1986). Similarly, Wang et al. (2023) conceptualise AIL across the dimensions of *awareness*, *usage*, *evaluation*, and *ethics*, while Hermann (2022) emphasises data collection and processing, human agency in AI usage, as well

as evaluating AI's biases, selectivity, and its overall societal impact as part of AI literacy. These examples illustrate the breadth of definitions and approaches in the field, all of which include the unifying elements of human proficiency in interacting with AI, while maintaining a critical stance on the technology itself, its outputs and ethical implications (c. f. Pinski and Benlian 2024).

Various examinations of the learning design(s) and didactic approaches of fostering AIL reveal a heterogeneity not only in the competencies focused on but also in the subject areas and learners addressed to impart it (e. g. Casal-Otero et al. 2023; Cetindamar et al. 2024; Chetty 2023; Kong et al. 2021; Wolters et al. 2024). By selecting specific AI-related subject areas, research on AIL distinguishes between the assumed educational needs of its target groups. For instance, studies on K-12 settings reveal that AIL initiatives primarily focus on introducing students to the basic tenets of AI and cultivating a foundational understanding of its workings, as well as recognising AI-generated artefacts as such (e. g. Casal-Otero et al. 2023; Touretzky et al. 2019). Transitioning to HE, the emphasis broadens to include comprehensive, discipline-specific AI learning, empowering students to apply AI principles analytically, ethically, and creatively within specific fields of study (e. g. Alamäki et al. 2024; Laupichler et al. 2022a; Sengewald and Tremmel 2024). Within adult education, especially in workplace-centred learning environments, the focus is on acquiring advanced, job-relevant AI skills, promoting continuous professional development and lifelong learning (e. g. Buchgraber-Schnalzer et al. 2025; Rafique et al. 2025; Tenberga and Daniela 2024).

Three research syntheses, which summarise the state of research on AIL in adult education up to 2023, reveal that the number of publications on the topic increases exponentially, but the quality of the synthesised studies varies (Almatrafi et al. 2024; Laupichler et al. 2022a; Wolters et al. 2024). While the studies included were unanimous in terms of the range of topics they covered, significant heterogeneity in the core competencies, skills, and abilities attributed to AIL could be detected (ibid.). Research desiderata were particularly identified in the theoretical foundations of learning materials for specific learner groups, in technology-supported teaching and learning scenarios, and in the measurement of learning outcomes (ibid.).

However, the systematic reviews introduced above cannot be considered exhaustive, as Laupichler et al. (2022a) conducted their literature search prior to the publication of OpenAI's ChatGPT, which has had a transformative impact on the educational sector (Chan and Colloton 2024). Furthermore, the systematic review by Wolters et al. (2024) is limited by its exclusive focus on English-language literature, its reliance on two databases only, and its literature search conducted in 2023. The latter limitation applies to the review by Almatrafi, Johri, and Lee (2024) as well.

Given the accelerated advancement of AI technologies and the increased public focus on the topic in recent years, a comprehensive update to these reviews seems imperative. Moreover, while extensive literature exists on individual educational contexts, potential

synergies between HE and CFE, such as shared educational formats or those adaptable to multiple contexts, remain insufficiently explored. Bridging this gap promises to enhance our understanding of how higher education institutions can effectively support (future) professionals in developing competencies, skills and abilities needed to thrive in workplaces affected by AI (c. f. Fleischmann et al. 2024).

3. Method

A mapping review «aims at categorizing, classifying, characterising patterns, trends or themes in evidence production or publication» (Booth 2016, 14), and therefore appears to be a suitable method for answering the pre-defined research questions of this study. The decision to conduct a mapping review rather than a systematic review merits explicit methodological justification, as the two approaches serve distinct purposes and yield different forms of knowledge (Grant and Booth 2009). Mapping reviews are particularly suited to emerging, heterogeneous fields where the primary aim is to identify, categorise, and chart the breadth of existing literature rather than to synthesise evidence towards specific intervention effectiveness or to answer tightly defined research questions (James et al. 2016). In contrast to systematic reviews, mapping reviews prioritise comprehensiveness and descriptive analysis to reveal gaps, clusters, and trends across diverse study types, methodologies, and contexts (Campbell et al. 2023). Moreover, this method was selected due to its capacity to capture the complexity of the construct, that is AIL, as well as for its assumed ability to reflect both the somewhat specific German-speaking pedagogical and «mediendidaktischen», as well as the international didactic, learning design and technology-enhanced learning discourse on AIL (Kerres 2025; Marín et al. 2023).

Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, the review encompassed the following standardised steps (Gough et al. 2012; Zawacki-Richter et al. 2020; Page et al. 2021): firstly, the study was registered at an official review repository (Open Science Framework), followed by scoping searches on the matter which lead to the development of an exhaustive search string in German and English as well as the selection of suitable databases. The following steps included conducting two rounds of literature searches with predefined exclusion and inclusion criteria. Titles and abstracts were screened to determine the eligibility of the studies before developing a coding scheme to extract information of interest during full-text screening. Subsequently, the coded data were analysed and discussed to answer the proposed research questions.

3.1 Search Strategy

In order to develop a suitable search string, we first drew upon terminology identified through preliminary scoping searches. Subsequently, the thesaurus function of the databases searched was used to detect synonyms or related terms. In doing so, we collaborated with a leading information scientist from Friedrich-Alexander-Universität Erlangen-Nürnberg. The search string incorporated both English and German terms (Tab. 1) to reflect linguistic differences between the German-speaking and international fields of educational research (Marín et al. 2023).

Biases in search strategies deriving from «messy constructs» (Pajares 1992) and linguistic peculiarities in national and international discourses are a well-known issue, especially in the context of mixed-method syntheses (Kerres 2025; Köstler 2023; Marín et al. 2023; Spante et al. 2018). We addressed this challenge by including related terms to AIL and CFE in the search strings to avoid missing relevant literature, and by clearly stating reductions in the search string as limitations (see Chapter 6). Nevertheless, articles were only included for data extraction if a central usage of the term *AI literacy* could be ascertained to reduce linguistic bias. Moreover, given our research interest in both formal and non-formal formats of CFE and the aim to apply suitable English terminology for the field, the chosen terminology derives from the *International Standard Classification of Education* (UNESCO Institute for Statistics 2012) and the *International Standard Classification of Education – Fields of education and training 2013* (UNESCO Institute for Statistics 2015).

The chosen databases were Scopus, ERIC, IEEE Xplore, and FIS Bildung, as they are either well-established in the field of educational sciences, list both journal articles and conference papers or cover the interdisciplinary nature of AIED (Gusenbauer and Haddaway 2020; Zawacki-Richter et al. 2019). The decision to omit Web of Science was made in accordance with the recommendation provided by the consulting information scientist, who advised against its inclusion due to the substantial overlap it exhibits with Scopus. The initial search for the extant research between 2022 and 20 February 2025 yielded 5,121 records, followed by 883 additional articles published between February and 15 May 2025. Moreover, singular items were added manually if the search string missed them. All entries were imported into systematic review software EPPI Reviewer 6.0 (Thomas et al. 2025). After removing 1,991 duplicates detected by the software, 4,013 publications were included for the screening of titles and abstracts (see Fig. 1).

Categories	Search terms according to the languages included	
	ENGLISH	GERMAN
AI	(«Artificial Intelligence» OR «AI» OR «ChatGPT» OR «GenAI» OR «Generative AI»)	(«Artificial Intelligence» oder «AI» oder «Kuenstliche Intelligenz» oder «KI» oder «ChatGPT» oder «Chat GPT»)
AND		
Literacy	(«literacy» OR «literacies» OR «skills» OR «competenc*»)	(«literacy*» oder «literacies» oder «Kompetenz*» oder «Fähigkeit*» oder «skills»)
AND		
Higher Education	(«Higher Education» OR «Tertiary Education» OR «Postsecondary Education» OR «Universit*» OR «Undergraduate Student*» OR «College Student*» OR «Postgraduate Student*»)	(«Hochschul*» oder «Hochschulbildung» oder «Universitaet» oder «universitae*» oder «Stud*»)
OR		
Continuing and Further Education	(«Adult Education» OR «Vocational Education» OR «Vocational Training» OR «Corporate Training» OR «Further Education» OR «Further Training» OR «Professional Education» OR «Adult Learning» OR «Lifelong Learning»)	(«beruflich*» oder «Fortbildung» oder «Weiterbildung» oder «Training» oder «Erwachsenenbildung»)

Tab. 1: The search strings.

3.2 Inclusion / Exclusion Criteria and Screening

To ensure inter-rater reliability, both authors double-screened a subsample of 100 articles on title and abstract, achieving substantial agreement (Cohen's $\kappa=0.77$). After resolving four disagreements through discussion, the remaining 3,913 articles were screened based on their titles and abstracts, and 278 on their full texts. The application of additional exclusion and inclusion criteria (see Tab. 2 and Fig. 1) led to a final corpus of 142 articles, accounting for approximately 3.5 % of all entries found in the database search.

The decision to include both full and short conference papers alongside peer-reviewed journal articles was made to account for the field's rapid development, while also recognising the time lag in peer-reviewed journal publications. Furthermore, both qualitative and quantitative studies were included, as this review aims to go beyond a numerical synthesis of research, and especially qualitative data can assist «in the interpretation of the significance and applicability of the review in making recommendations to practitioners and planners» (Dixon-Woods et al. 2001, 126).

Inclusion criteria	Exclusion criteria
Published between January 2022 and May 2025	Published before 2022
Empirical or theoretical papers	Opinion pieces, commentaries or editorials
Primary research	Secondary or tertiary research
Scientific journal articles or conference publications (both full and short papers)	Other types of publications, such as books, book chapters, editorials, posters
Higher education, continuing and further education, vocational education or adult education	Other educational sectors, e.g. K-12
Focuses on AI literacy	Articles that do not focus on AI literacy or solely introduce AI literacy as a related concept or study finding
Published in English or German	Not English or German

Tab. 2: Inclusion and exclusion criteria.

3.3 Data Extraction and Data Analysis

We developed a comprehensive coding scheme incorporating both deductive and inductive categories to analyse the studies narratively and thematically (Dobricki et al. 2020; Kuckartz and Rädiker 2024). The first part of the coding scheme focuses on identifying study characteristics, including geographical data, methodological design, and study population, along with the understanding of AIL referenced.

The second part of the coding scheme aims to extract information on the theoretical background, key components of AIL addressed, teaching and learning objectives, activities, and the learning design selected to promote AIL. In addition, the corpus was coded on AIL assessment formats; however, these results are not included in this article. The studies included were split between us to code the full text¹. Any disagreements that occurred were reconciled through discussion. Reported in this article are mainly univariate analyses and descriptive results.

¹ To ensure the transparency of this study, the detailed coding system, along with a table of the studies included, is accessible via <https://osf.io/5pv9b/>.

4. Findings

4.1 Study Characteristics

The findings reveal a notable surge in publications since 2022. While in 2022, only four papers addressing AIL in HE or CFE were published that could be included in this review, by May 2025, these annual publications had already risen to $n=50$. The 142 studies included could be attributed to a total of 96 countries, based on the geographic locations mentioned in the text, and if no country of study was stated, by the institutional affiliations of the first two authors ($n=27$ articles).

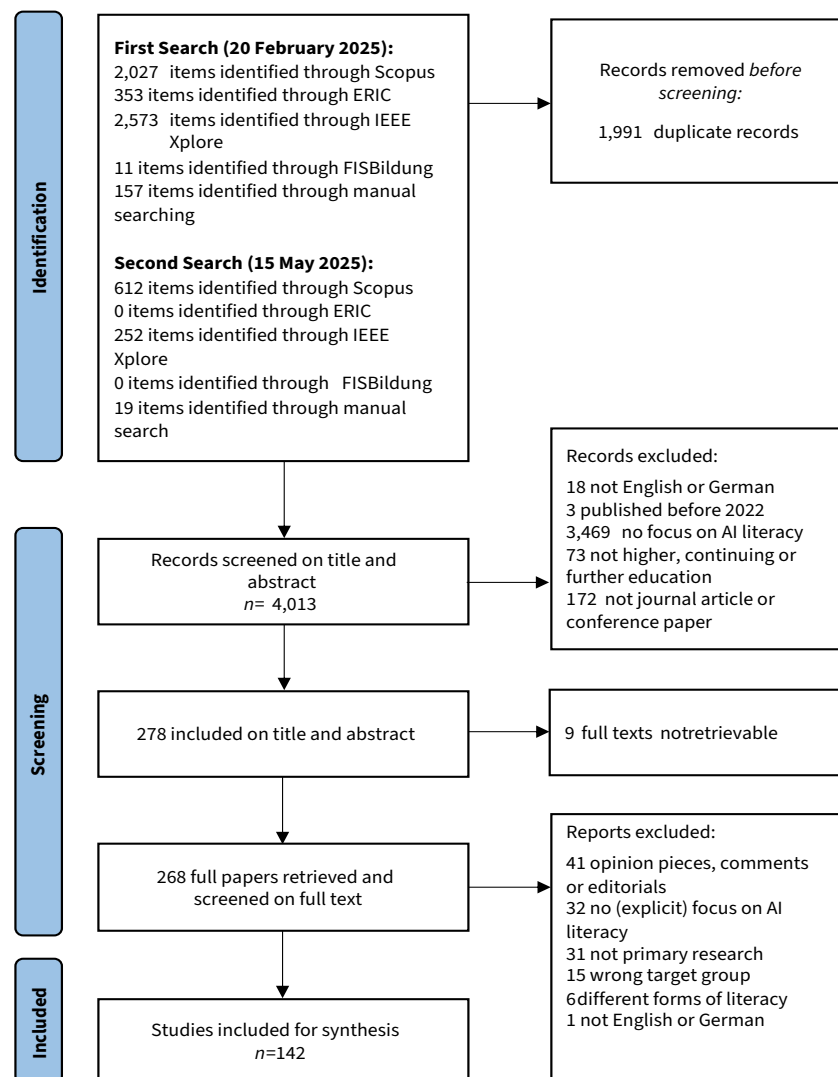


Fig. 1: PRISMA flow chart.

In terms of the geographical context of research on AIL in HE and CFE, China (including Hong Kong) takes the lead ($n=29$), followed by the USA ($n=25$) and Germany ($n=19$). While Germany's third position could be due to bias arising from including a database located in the German-speaking countries, it seems noteworthy that only one article written in German was included in the corpus (Weber et al. 2023).

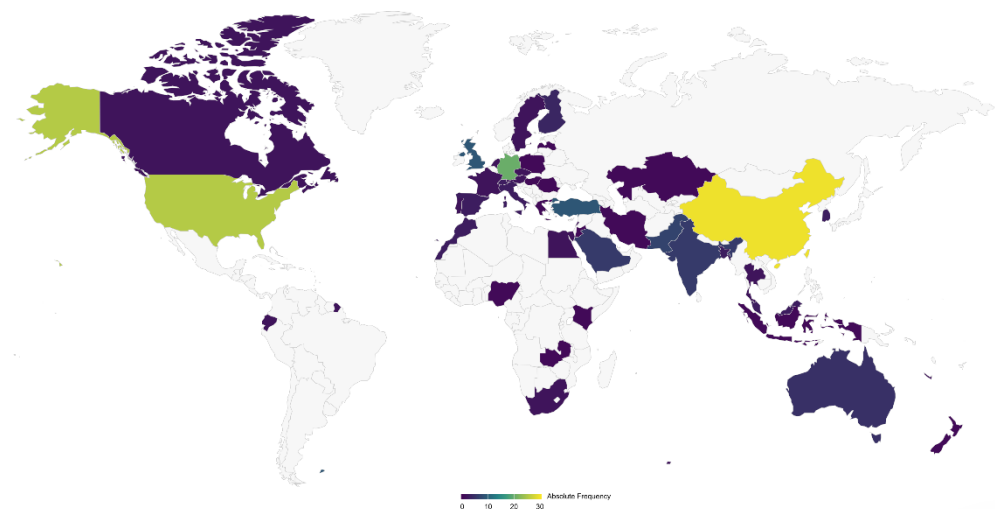


Fig. 2: Countries of origin of the research included per statement in the paper or country affiliation of the first authors. This figure was generated with R (Arel-Bundock et al. 2023).

The corpus consists predominantly of journal articles (77 %), with conference papers accounting for 23 %. Moreover, the corpus encompasses 94.4 % empirical and 5.6 % theoretical-conceptual papers. The research approaches applied range from mainly quantitative ($n=77$) to mixed-method ($n=37$) and qualitative research ($n=20$).

Moreover, striking differences in terms of educational context are visible: The highest percentage of studies reviewed address HE as their field of study (71.1 %, $n=101$), followed by research on CFE (12.0 %, $n=17$), studies addressing HE *as well as* CFE (6.3 %, $n=9$), adult education (3.5 %, $n=5$) and papers addressing multiple educational contexts (e. g. HE and K-12; 3.5 %, $n=5$) or presenting the development of AIL scales and assessment formats (3.5 %, $n=5$). It is imperative to consider this differential weighting of educational contexts when interpreting the results.

Regarding the thematic foci of the studies, a heterogeneous picture emerges, ranging from AIL of (subject-specific) groups of students in HE (28.2 % of the studies, $n=40$), teaching and learning scenarios to foster AIL or GenAIL (16.2 %, $n=23$), to AIL of specific occupational groups (10.6 %, $n=15$ studies).

4.2 RQ1. Which definitions, frameworks and models are referenced in the context of AI literacy in higher, continuing, and further education?

128 studies state a definition of AIL, while 14 studies (e. g. Akca Sumengen et al. 2025; Buchgraber-Schnalzer et al. 2025; Cao et al. 2024) use the term without providing a comprehensive definition. A total of 154 definitions of AIL are referenced in the corpus, with 25 studies presenting their own understanding of AIL, such as Cardon et al. (2023), Laupichler et al. (2023b) or Pinski and Benlian (2023). Of the 154 definitions referred to, the ones that are cited the most are Ng et al.'s (2021a, 2021b) with 77 articles, and Long and Magerko's (2020) with 76 articles stating their definition of AIL. Conversely, 96 definitions (62.3 %) are reported singularly, for example, those of Alamäki et al. (2024), Ayanwale et al. (2024) or Annapureddy et al. (2025). Interestingly, several studies in the corpus ($n=34$, 23.9 %) base their understanding of AIL on definitions, initially written in and for different educational contexts, primarily K-12 (16 % of definitions stated; e. g. AI4K12 Initiative 2025; Casal-Otero et al. 2023; Eguchi et al. 2021). These are referenced when defining AIL and its components, even if the study itself was set in HE (e. g. H. Zhang et al. 2023; being cited in O'Dea et al. 2024) or CFE (Su et al. 2023; being cited in Rafique et al. 2025). In an attempt to summarise and cluster the sources referenced in the corpus to define AIL, Černý's (2024, 5) cluster was partly adopted, edited, and extended to nine groups of AIL understandings (see appendix, Tab. 3, as well as Fig. 3). Accordingly, the largest group of research drawn upon grasps AIL as (part of) a broad structure of proficiency, knowledge, competencies, abilities, and/or skills ($n=62$ papers stated in the corpus), followed by 30 studies understanding the construct as a composite structure of knowledge, competencies, abilities, and/or skills related to Bloom's (revised) taxonomy (Bloom et al. 1969; Anderson and Krathwohl 2006). For a comprehensive overview of the further cluster of AIL definitions and understandings, such as, for instance, studies perceiving AIL as competencies, skills, and abilities related to one's profession, specific AI literacies such as Generative (Gen)AI literacy or Critical AIL, please see the appendix.

4.2.1 Competencies, Skills, and Abilities Linked to AI Literacy

In a subsequent step, the AIL model developed by Long and Magerko (2020) was employed as a blueprint to identify key competencies associated with AIL, which comprises *Recognising AI, Understanding Intelligence, Interdisciplinarity, General vs. Narrow AI, AI's Strengths and Weaknesses, Imagine Future AI, Representations, Decision-Making, Machine Learning Steps, Human Role in AI, Data Literacy, Learning from Data, Critically Interpreting Data, Action and Reaction, Sensors, and Ethics* (ibid.). This model was selected as it is one of the two most frequently cited approaches to AIL in the corpus and is more distinctly differentiated than the one by Ng et al. (2021a, 2021b), which was deemed helpful for categorising the vast array of skills and competencies stated in the corpus. Moreover, the model's compounds are embedded in and supported by subsequent research (e. g.

Hornberger et al. 2023; Schallert-Vallaster et al. 2025). The results indicate that ethics-related competencies in dealing with AI (mentioned in $n=115$ studies, 81%) and the ability to evaluate AI models critically ($n=102$, 71.8%) are the key areas of competence referred to in the corpus. Comparing the 16 areas of competencies introduced by Long and Magerko (2020) between HE and CFE, as well as in studies addressing both educational contexts, it becomes apparent that ethical abilities and critical evaluation competencies regarding AI are the most frequently cited and therefore most emphasised in all three contexts as well.

However, since the competencies listed in the model did not exhaustively cover the components of AIL recurring in the corpus, we inductively coded additional ones noted as well. It is important to note that the terms *competencies*, *skills*, *abilities*, and *proficiency* are all used to delineate and describe the components of AIL in this review, as these terms are frequently used interchangeably in the corpus and are rarely clearly distinguished or explicitly defined. To avoid any potential misinterpretation at this juncture, it seems imperative to use the original terminology of the studies analysed whenever possible and subsequently address the need for conceptual clarity in a forthcoming article.

A further $n=66$ complementary competencies, skills, and abilities could be identified; the most frequently cited in this context are the ability to apply AI (stated in $n=80$ studies concerning HE, $n=13$ studies concerning CFE, and $n=15$ studies addressing both), understanding AI ($n=71$ HE, $n=15$ CFE, and $n=7$ addressing both), understanding the functionality of AI technologies ($n=39$ HE, $n=4$ CFE, and $n=4$ addressing both), human accountability in the context of AI ($n=33$ HE, $n=4$ CFE, and $n=5$ addressing both) and the ability to assess AI output ($n=32$ HE, $n=5$ CFE and $n=2$ addressing both)².

4.2.2 Theories, Frameworks, and Models Referenced in the Corpus

A total of $n=117$ frameworks, theories or models are stated as theoretical background in the corpus, with $n=22$ papers presenting their own. At the same time, $n=20$ studies do not clearly state such theoretical foundations, but instead provide an overview of research findings relevant to their topic. The theoretical background referenced to, can be clustered into six groups: (Gen)AIL related (32.5% of $n=117$ theoretical underpinnings referenced), education or educational psychology related (23.1%), AI related (12.8%), educational technology (EdTech) related (10.3%), AIED related (8.5%), other disciplines related (8.5%) and the discipline-specific AI related theoretical background (4.3%).

2 For an overview of the comparison of other competencies, skills and abilities listed in the corpus as belonging to AIL, see the corresponding table at <https://osf.io/5pv9b/>.

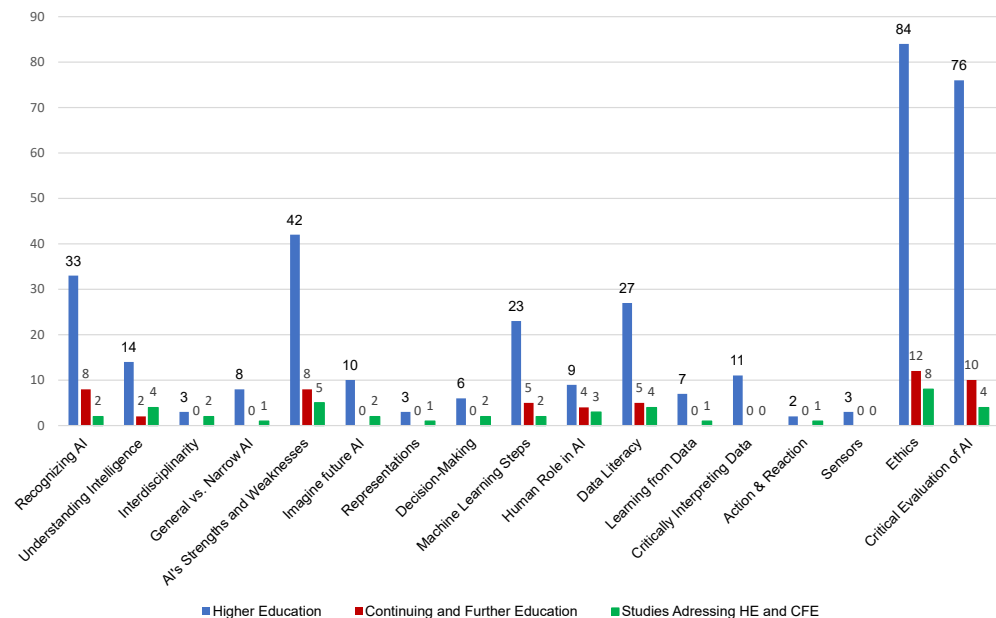


Fig. 3: Distribution of core competencies of AI literacy as per Long and Magerko (2020) by educational context of the studies included.

Regarding (Gen)AIL frameworks and theories ($n=38$ in total), the most frequently cited are the frameworks by Ng et al. (2021a, 2021b, 2022a, 2022b) with $n=26$ studies, and Long and Magerko (2020), cited in $n=25$ studies. Further papers on AIL, referred to as frameworks, range from Cetindamar et al.'s (2024) *AIL framework for employees of digital workplaces*, Pinski and Benlian's (2023) *AIL framework*, Wang and Wang's (2025) *post-humanist approach to AIL*, Allen and Kendou's (2024) *ED-AI Lit framework*, to Laupichler's (2022a, 2023b) *Non-expert AIL framework*³. These theoretical approaches consistently address elements such as competencies, skills and abilities in understanding, using, evaluating and adopting a critical-ethical stance on AI. In a different line of theoretical underpinnings, researchers such as Beninger et al. (2025) argue that different types of AI require distinct forms of literacy. Therefore, while rooted in technology education, they add a socio-ethical component to the previously listed elements when proposing a synthesis of GenAI literacy frameworks.

Furthermore, research on AIL in HE and CFE also draws upon various approaches that can be attributed to AIED ($n=10$ stated in the corpus), such as the *Machine Learning Education Framework* by Lao (2020), or the *AI-TPACK* by Ning et al. (2024). AI technology itself is referenced through theories and frameworks ($n=15$ stated in the corpus), such as the *AI Narratives Theory* (Sarker et al. 2018), the *3wAI Framework* by Bozkurt (2024) or the *Five Big Ideas Framework* by Touretzky et al. (2019). In contrast, discipline-specific

³ A comprehensive overview of the referenced frameworks, theories and models can be accessed via <https://osf.io/5pv9b/>.

AI-related frameworks ($n=5$ in the corpus), such as the *Teacher AI Literacy Framework* by Chiu et al. (2024) or the *Clinical Laboratories' Knowledge, Skills, and Technological Readiness Framework* (Wang et al. 2019), operationalise AI competencies, skills and abilities within the context of their discipline. Additionally, theories associated with EdTech are frequently stated (cited in $n=12$ studies of the corpus), including, for example, the *Technology Acceptance Model* (Davis 1989) or the *Task-Technology Fit (TTF) Model* by Goodhue and Thompson (1995). Additionally, educational and educational psychology theories ($n=27$ stated in the corpus) such as Bozkurt's (2015; 2019) *Framework of Open and Distributed Learning*, Ryan and Deci's (2017) *Self-Determination Theory*, or Bandura's (1999; 1977) *Self-Efficacy and Social Learning Theories* are frequently used as theoretical background to investigate relationships between AIL and other variables, including, among others, GenAI risk awareness (Wu et al. 2025), AI trust, or AI dependency (Zhang et al. 2025).

Given the scope of the cited frameworks, models, and theories, which span multiple disciplines and various research traditions, the interdisciplinary nature of the research field becomes evident. Furthermore, this broad range creates an impression of attempts to depict the dynamic features and use cases of AI by drawing on a wide range of theoretical backgrounds. Additionally, the numerous definitions of AIL highlight efforts to grasp the construct from different perspectives, while content overlaps in definitions and frameworks become increasingly apparent (see Tab. 3).

4.3 RQ2. Which teaching and learning objectives, didactic approaches, and methods are designed to foster AI literacy in both educational sectors?

4.3.1 Teaching and Learning Objectives

To detect teaching and learning objectives in studies addressing teaching and learning scenarios ($n=54$, 38 % of the corpus), we turned to Bloom's revised taxonomy of educational objectives by Anderson and Krathwohl (2006). The latter structure knowledge in the dimensions of factual, conceptual, procedural, and metacognitive knowledge, combining those dimensions with the cognitive processes of remembering, understanding, applying, analysing, evaluating, and creating (ibid. 2006). A list of action verbs in English and German associated with these cognitive processes was used to code and analyse teaching and learning objectives stated in the corpus (ibid. 2006; Gogus 2012).

The analysis revealed that teaching and learning objectives were most frequently defined at the taxonomy levels *Apply* ($n=46$), *Understand* ($n=42$), and *Evaluate* ($n=33$). Somewhat surprisingly, the highest taxonomy level *Create* ($n=25$) was not referred to in the least of studies, but rather *Analyse* ($n=15$). Studies describing the former objective, for instance, tasked pre-service teachers with generating AI-supported quizzes and assessment questions (Abdulayeva et al. 2025) or with writing Python code to program a robot as part of a project-based learning (PBL) approach (Bellás et al. 2024).

4.3.2 Didactic Approaches

Of 48 papers addressing a teaching and learning scenario to foster ALL, 54.1 % ($n=26$) do not state a mode of delivery. 11 studies introduce or refer to distance education formats (e.g. Hachem and Heintz 2024; Ou et al. 2024). Another ten studies investigate blended formats such as flipped classrooms (e.g. Laupichler et al. 2022b), classes offered in hybrid (Korte et al. 2024), asynchronous activities as part of a course (e.g. Bellas et al. 2024) or a hybrid educational escape room (DiPaola et al. 2023), while seven studies address face-to-face scenarios (e.g. Alamäki et al. 2024; Beninger et al. 2025; Chen and Qin 2023). Moreover, it needs to be stated that two studies investigate multiple modes of delivery and were coded accordingly: Laupichler et al.'s (2022b) study, focusing on a Massive Open Online Course (MOOC) and a flipped classroom, as well as Xie et al.'s (2023) study examining a combination of a MOOC and in-person lectures.

Regarding didactic approaches, the studies indicate a clear tendency towards teacher-centred formats such as presentations or lectures, summarised under the code *Instruction* ($n=26$), followed by collaborative ($n=13$) and interactive learning ($n=11$) (c.f. Figure 3). However, $n=32$ studies combine multiple didactic approaches in their study design or results. For example, Alamäki et al. (2024) merge teacher-held presentations with problem-based learning, Allen and Kendou (2024) address interactive, self-regulated, collaborative and project-based learning to promote ALL, and Hönigsberg et al.'s (2025) courses blend collaborative, project-based and technology-mediated learning approaches.

Moreover, $n=16$ individually coded didactic approaches catch the eye of the observer. For example, technology-mediated (Hönigsberg et al. 2025) and tool-mediated learning approaches (Markauskaite et al. 2022) are only examined singularly, as are experiential (Modran et al. 2024), immersive (Dong et al. 2025), and inquiry-based learning (Abdulayeva et al. 2025). Interestingly, however, only 22 studies explicitly mention the usage of specific AI tools in the teaching and learning scenario presented in their paper, of which 20 are affiliated with HE (inter alia Erdem Coşgun 2025; Gómez-Rodríguez et al. 2024; Ngo and Hastie 2025), and two with CFE (DiPaola et al. 2023; Xie et al. 2023).

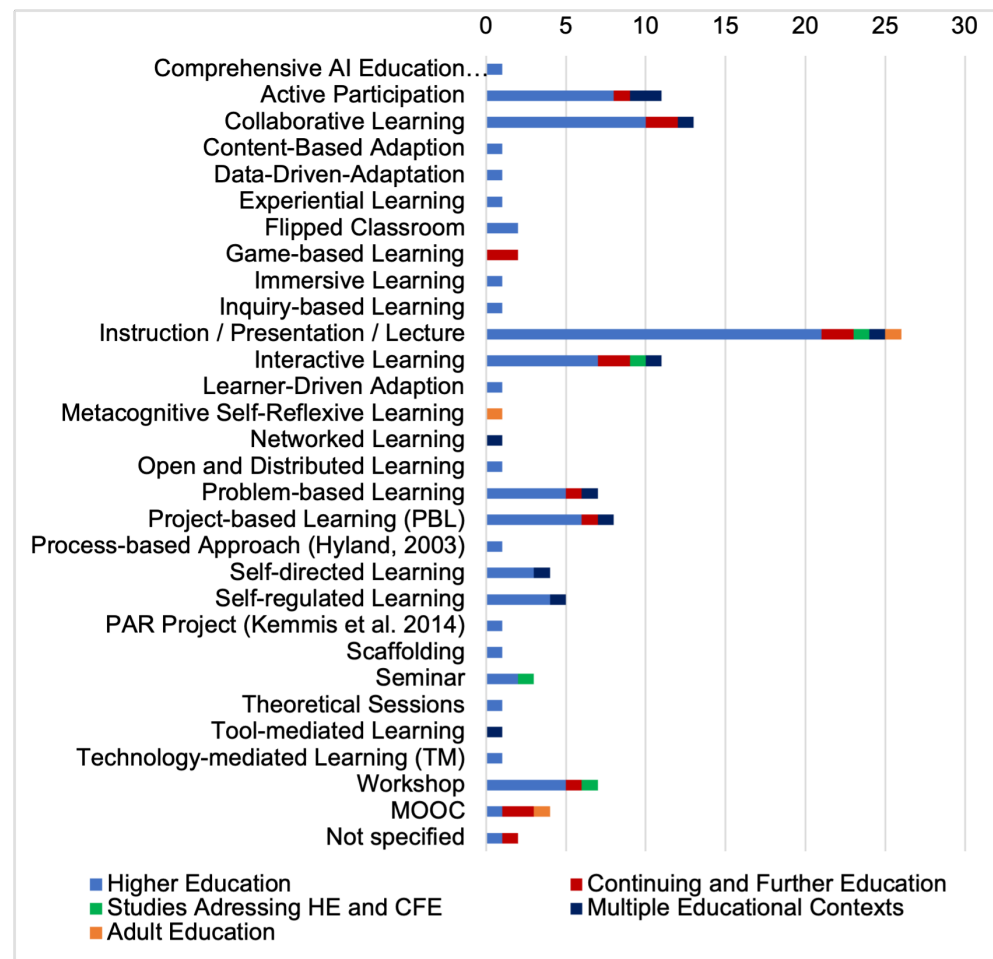


Fig. 4: Didactic approaches drawn upon or investigated per number of studies and educational context. The terms stated are the terms chosen in the articles.

Tentative attempts to compare studies in HE with those addressing CFE regarding their learning design reveal several areas of overlap, but few differences. While both studies in both educational fields appear to exhibit interactive, collaborative and teacher-centred approaches, a divergence in the variety of didactics stated in each educational field is evident (see Fig. 4). However, the examination of the extant literature reveals a paucity of research on game-based learning in HE on AI. Indeed, the only studies in the corpus that address this didactic approach are those by DiPaola et al.'s (2023) and Buchgraber-Schnalzer et al.'s (2025), both focusing on CFE.

4.3.3 Curricula and Topics Taught to Foster AIL

38 studies state specific curricula and topics taught within AIL-related teaching and learning scenarios. The most frequently stated subject areas across the entire corpus are *AI Ethics* and *Machine Learning* (both in $n=17$ studies), followed by *AI Usage* ($n=16$), *Introduction to AI* ($n=16$), and *Fundamental AI Methods and Concepts* ($n=14$). Meanwhile, singular cited inductive codes constitute the largest group in the coding scheme's section for teaching and learning contents ($n=40$ singular topics in total). Topics such as *AI in the Healthcare Sector*, *Designing Lessons with AI*, *Bayesian Reasoning*, *AI Related Statistics* or *GenAI Usage in Academic Writing* are amongst them.

When comparing the curricular contents taught to promote AIL across different educational sectors, similarities and differences become apparent. While *Machine Learning* and *AI Ethics* are the most frequently covered topics in HE studies ($n=13$), studies related to CFE most often highlight *AI Ethics* and *AI Usage* (both in $n=3$ studies) as key themes targeted in education on AI.

Topics that are solely addressed in the context of HE ($n=32$) range from content related to the history of AI, the technology and mechanisms behind AI (e. g. algorithms, neural networks, sensors, actuators, knowledge representation, supervised and unsupervised learning techniques) to rather vaguely or broadly titled topics such as an *Introduction to AI and ChatGPT* (Younis 2024), *Defining AI, Machine Learning and Deep Learning* (Chen and Qin 2023), *Distinguishing AI Science from Science Fiction* (Biswas et al. 2025), or *AI-supported Educational Gamification* (Gómez-Rodríguez et al. 2024). Conversely, Buchgraber-Schnalzer et al. (2025) are the only scholars to address the topics of *Data Literacy* and *Statistics* (Buchgraber-Schnalzer et al. 2025) as part of their AIL curriculum for healthcare professionals.

5. Discussion

This paper maps the field of research on AI literacy in higher, continuing, and further education from 2022 to May 2025, examining study characteristics, AIL definitions, and theoretical underpinnings, as well as thematic foci in education on AI, didactic approaches, and learning design. A pronounced focus lay on attempts to compare research related to AIL in HE and CFE. Initially, 4,013 articles were screened based on titles and abstracts, 278 on full text, and ultimately 142 were deemed eligible for data extraction.

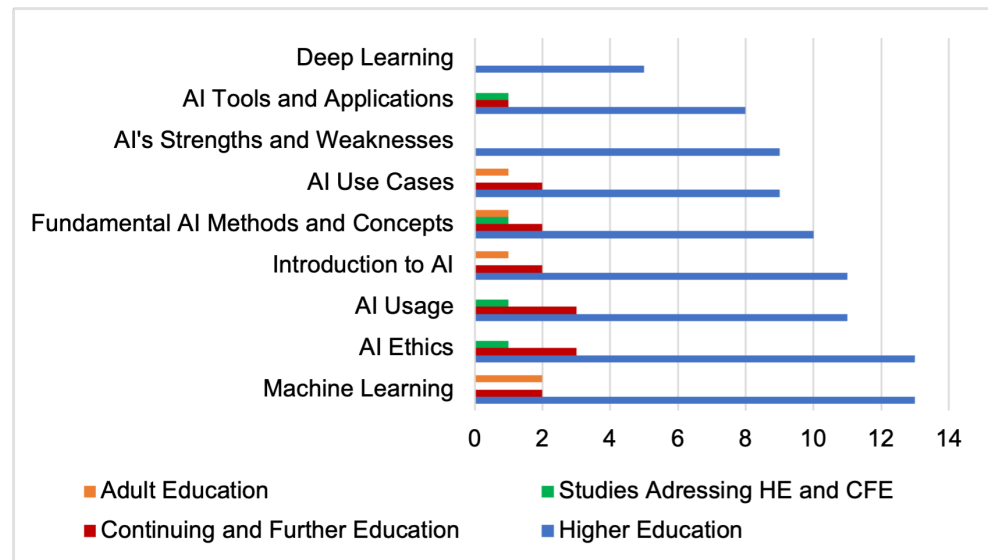


Fig. 5: Comparison of the ten AIL-related topics most frequently addressed in the study corpus.

5.1 Overarching Findings

In accordance with Laupichler et al. (2022a), research from North America and China dominates the exponentially expanding literature in the field since 2022. These results seem somewhat unsurprising, given North America's and China's leading positions in AI technology development and advancement, as well as their longer-established AI&ED policies and strategies (Schiff 2022; Ministry of Foreign Affairs of the People's Republic of China 2025; Executive Office of the President of the United States 2025). However, from a geographical standpoint, the current state of research appears more diverse than in previous years (Laupichler et al. 2022a). The corpus comprises studies from 96 countries, with Asia ($n=68$) being the most represented region, followed by Europe ($n=46$), North America ($n=26$) and Africa ($n=11$). As significant disparities in the representation of geographical regions were detected, it is advisable to extend funding and increase the visibility of research on the topic from Africa, Oceania and South America to complement and diversify perspectives from Western and technophile countries (Bedenlier et al. 2025; Toledo 2024). This includes mitigating linguistic homogeneity in future research syntheses such as this one.

Quantitative studies and research on AIL in the context of HE could be detected as the study designs and educational contexts investigated most often. While mixed-method designs are increasingly adopted in AIL research, qualitative research still appears to be underrepresented. These findings align with Zawacki-Richter et al.'s (2019) results, whose call for «innovative and meaningful research and practice with AIEd» (ibid. 2019, 20) therefore remains relevant and can be extended to AIL in CFE.

A third overarching finding is the underrepresentation of studies on AIL in CFE, possibly caused by convenience sampling in research on HE due to authors' institutional affiliation (e. g. O'Dea et al. 2024; Promma et al. 2025) and a potential bias in the search string, which does not cover the entire range of terminology used to describe formal and non-formal educational formats in CFE. As studies on AIL in CFE are significantly underrepresented in the field, the comparison of didactic approaches, learning designs and definitions of AIL therefore somewhat lacks rigour, which is why findings and their interpretations are not to be generalised. However, the significant disparity between studies on AIL in HE and those in CFE highlights a pressing need to address this underrepresentation, as HE and CFE are interconnected parts of lifelong learning (European Commission n. d.). As students in HE transition to employees or leaders, fostering agile competencies and skills to adapt to, use, and analyse (AI) technologies critically and ethically appears imperative, as Cetindamar et al. (2024) conclude. CFE formats, understood as part of a lifelong learning process, could address this need (ibid.), but require in-depth empirical investigation. Moreover, the overrepresentation of HE in AIL research results in a narrowed scope of didactic approaches, learning designs, and findings. As Domínguez Figaredo and Stoyanovich (2023) critically point out regarding research on AIL in K-12, such an imbalance limits the broader applicability of research findings to other groups of learners.

5.2 Defining AI Literacy and Theoretical Underpinnings

In response to RQ 1, a wide variety of AIL definitions ($n=154$), theories, frameworks and models ($n=117$) used to investigate AIL in HE and CFE could be identified. The definitions referred to were clustered in the categories *AIL as competencies, skills and/or abilities for everyday life*, *AIL as a prerequisite for (future) success in the labour market and competencies, skills and/or abilities related to one's profession*, *AIL as (part of) a broad structure of knowledge, competencies, abilities, and/or skills*, *AIL as a composite structure of knowledge, competencies, abilities and/or skills based on Bloom's Taxonomy (1956)*, *AIL as a form of (socio-) technological knowledge, abilities, skills and/or competencies*, *GenAIL*, *Socio-cultural AIL*, *Critical and/or responsible AIL*, and a *Posthumanist Approach to AIL*, partly deriving from, and partly expanding Cerny's (2024) work (c. f. Tab. 3 in the appendix). This cluster shows the magnitude of definitions, some being rather distinct, but most share similar core components such as understanding AI, recognising AI, AI usage, AI evaluation, and AI ethics, as noted by Almatrafi et al. (2024) as well. Following Pinski and Benlian's (2024, 3) conclusions, it can be stated that a unifying element lies in striving for «holistic proficiency regarding different subject areas of AI». This distribution demonstrates three phenomena. Firstly, it highlights the current prevalence of broad competencies, abilities, skills, and knowledge structures in the definition of AIL referenced. Secondly, it indicates an increasing shift toward defining and distinguishing

between GenAIL (e.g. Annapureddy et al. 2025), Critical AIL (e.g. Carolus et al. 2023) and Socio-cultural AIL (e.g. Eguchi et al. 2021) as key literacies that adult learners need to develop for their personal and professional development (e.g. Beninger et al. 2025; Kong, Cheung, and Zhang 2023). Thirdly, in accordance with Sperling et al. (2024), it can be stated that while using the term AIL inconsistently and sometimes vaguely, «research initiatives assume this knowledge to be of a specific type» (Sperling et al. 2024, 9).

Moreover, the wide fragmentation of definitions indicates and visualises the interdisciplinary approaches to investigating AIL, allowing for a rich but complex field of study that necessitates «interpretative flexibility» (Beninger et al. 2025, 3; MacCallum et al. 2023). We perceive this magnitude as a symptom of an emerging, fast-developing and interdisciplinary field. However, this diversity underscores a broader educational challenge: on the one hand, keeping up with extensive definitions of AIL, whilst gaining an understanding of which AIL definition and theoretical background appear suitable for the particular learning environment under investigation or in which one is working. On the other hand, distilling learning designs and didactic approaches to foster fluctuating competencies, skills and abilities needed for an uncertain future regarding AI(L) in careers and private lives, challenges educators. Furthermore, the high number of AIL definitions, approaches, and interchangeably used terms in the research synthesised can, through a critical AI&ED perspective (Holmes et al. 2025), be seen as a consequence of AI's fast enhancements and advancements, as well as educational research's attempt to keep pace with the growing market for AI tools and systems and its implications for education. However, «[k]eeping up to date with research and developments in multiple fields also requires time – something the rapid advancements in AI often do not allow, making it „difficult for academics ... to speak to the public and not to the archive” (Kathryn Conrad)» (Holmes et al. 2025, 13; quotation marks in the original). Addressing these challenges, there seems to be potential in developing integrative didactic approaches that align AIL with domain-specific, socio-cultural and critical competencies, skills and abilities, aiming for a balanced educational scope that supports learners not only in developing narrow AI-specific technological skills but also social accountability and agency in AI understanding, usage, reflection and criticism.

This leads to the competencies, skills and abilities linked to AIL within the study corpus. The prevalence of ethics-related competencies, abilities and skills, as well as the ability to critically evaluate AI, highlights the human role in AI usage and evaluation and points to a preference for fostering *hybrid intelligence* in HE and CFE, as de Witt (2024) proposes. Further competencies, skills and abilities addressed throughout the corpus relate to practical skills in applying AI technology ($n=111$) or to comprehension-related aspects of cognition, such as understanding AI ($n=105$) and its functionalities ($n=54$) (Anderson and Krathwohl 2006; Krathwohl 2002). However, the findings also expose gaps in AIL research on HE, specifically lacking foci on competencies, skills and abilities in critically evaluating one's AI usage ($n=0$ in HE; $n=1$ in CFE), proficiency in data science

($n=0$ in HE; $n=1$ in CFE) and related literacies, such as data, critical, rhetorical, information, functional, or social literacy (all $n=0$ in HE; $n=1$ in CFE). These findings seem to appear particularly interesting in light of Jaiswal et al.'s (2025) study on skill gaps between HE and the British AI industry, showing that skills in the field of data analysis and data visualisation are twice as frequently demanded by industry as they are taught in HE. A similar imbalance is also evident in the present data set regarding competencies, skills, and abilities in data science as part of AIL.

Furthermore, gaps in AIL research on CFE emerge regarding the explicit investigation of, e. g. competencies in allocating tasks to AI tools ($n=0$ in CFE; $n=2$ in HE), problem-solving skills as part of AIL ($n=0$ in CFE, $n=3$ in HE), the ability to manage legal AI issues ($n=0$ in CFE; $n=1$ in HE) or the capability to make free decisions regarding the usage of AI ($n=0$ in CFE; $n=7$ in HE).

However, particular emphasis must be placed on the underrepresentation of studies on CFE in the corpus of studies ($n=17$ studies on CFE vs. $n=101$ studies on HE), which reinforces the need to interpret these findings and comparisons with caution, which are, in conclusion, not to be generalised. It is probable that competencies being underinvestigated in research are nevertheless being fostered in pedagogical practice, or further gaps persist, which are not retrievable from the corpus analysed.

5.3 Didactic Approaches and Learning Design

The predominance of teacher-centred instructional methods in the corpus, such as presentations or lectures, does not seem surprising, given a still widespread lack of alignment between teaching and research in HE and multiple barriers to active learning formats on various institutional levels, e. g. workload, professional vulnerability or learners' task avoidance (Børte et al. 2023). However, while collaborative and interactive learning formats are catching up both in HE and CFE and active learning formats are getting combined with teacher-centred methods to some extent in the corpus, further engaging learning designs such as game-based learning are only explored in limited instances within the few extant studies on CFE (Buchgraber-Schnalzer et al. 2025; DiPaola et al. 2023). Moreover, the fact that the majority of studies examining or describing teaching and learning scenarios do not clearly specify a mode of delivery ($n=26$) makes it difficult to contextualise their results on didactic approaches and methods in their educational context.

Future research and practice should therefore strive to a) clarify and b) diversify didactic approaches and learning environments researched and implemented to ensure that investigations and approaches developed to foster AIL reflect the needs of adult learners as well as their agency and autonomy in the context of AI as prerequisites of successful lifelong learning (Grøndahl Glavind et al. 2023; Klemenčič et al. 2020; Long, Padiyath, et al. 2021).

A further salient question concerns the connections between this review's research questions and, consequently, the identification of potential patterns and discernible connections between the recurring theoretical frameworks and the pedagogical approaches employed within the corpus. Conscious reference to AI literacy definitions is only made in individual cases when presenting the pedagogical approaches applied (Abdulayeva et al. 2025; Aladsani 2025; Beninger et al. 2025; Chen and Qin 2023; De Silva et al. 2024; DeVasto and Palmer 2024; Dong et al. 2025; Hönigsberg et al. 2025; Kong, Cheung, et al. 2022; Kong, Cheung, and Zhang 2023; LaFlamme 2025; Richards 2023; Xie et al. 2023; Younis 2024). The studies referenced corroborate their didactic approach through the definitions of AI literacy referenced. Nevertheless, no discernible patterns emerge from this analysis. The question of whether a corresponding link was made in the design and implementation of a particular study remains largely speculative. However, we strongly advocate that in future research projects, and in particular intervention studies in the context of AI education, such decisions and theoretical underpinnings of the didactic approach under investigation should be made visible and thus comprehensible and verifiable.

6. Limitations

As with every research synthesis, this mapping review faces certain methodological limitations. Firstly, the review's quality hinges on the study designs and their descriptions in the studies included, which «can make it difficult to fully explore alternative interpretations of the data, as systematic reviews depend on the included studies' theoretical and methodological approaches» (Debets et al. 2025, 26). As no formal quality assessment is undertaken in mapping reviews, the studies included in this review are not appraised (Grant and Booth 2009). Furthermore, the inclusion of conference short papers poses risks in terms of their quality. However, to draw an exhaustive picture of a developing field, short papers that met the inclusion criteria were incorporated into the study. Secondly, as Bedenlier et al. (2020, 2025) observe, biases may occur due to the specified time period for study selection and the inclusion of articles written only in English or German. We are aware that research on AIL has been flourishing before 2022; however, this starting point was deliberately chosen due to OpenAI's launch of ChatGPT and its growing influence on HE and CFE ever since (Chan and Colloton 2024). Thirdly, the inconsistent terminology and so-called *messy constructs* in the context of AIL (e. g. AI competencies, AI competences, AI skills, etc.) and concerning the variety of formal and non-formal teaching and learning formats in CFE (e. g. further training, vocational training, in-service training, adult education, etc.) can limit the significance of the corpus. Fourthly, we are well aware that comparisons between didactic approaches to foster AIL in HE compared to those in CFE are complicated by the profound numerical differences in publications, and therefore need to be interpreted with caution. However, these differences need to be made visible in order to intensify research foci on the latter.

Lastly, despite our diligent efforts to execute each step of the review to the highest standards and to ensure high intercoder reliability, errors arising from overlooked information, research papers, or incorrect coding cannot be entirely ruled out.

7. Implications

The results of this mapping review open up multiple avenues for discussion among educators, learners, and researchers. Firstly, addressing the practical and empirical challenges that stakeholders in education face in an attempt to keep up to date with developments in (Gen)AI: The question arises, whether we need new or more adaptable models, theories and definitions of AIL in HE and CFE or should rather focus on the ways to foster agile AIL while deepening other sets of literacies, such as data, digital, media, technological, and – probably the most important – critical literacy. Based on the findings of this review and the heterogeneity in approaches, definitions, and frameworks it visualises, we suggest increasing focus on the latter. While frameworks are of paramount importance as guidelines and action plans, the constant publication of new or expanded AI literacy frameworks for various educational fields (see, for example, Hackl et al. 2026; OECD 2025) also requires subsequent attempts to translate them into practice. It is only in this manner that the opportunities and challenges inherent in the translation of these frameworks and guidelines from theory to practice become evident and can be addressed, discussed and adapted. In doing so, learners, their characteristics and needs must be prioritised, and changes in the field, as well as technological advances and highly critical aspects of AI technology and AIED, are to be proactively addressed. Such didactic advancements in research and practice would require educators in HE and CFE to advance their professional development in terms of AI literacy and being able to translate existing frameworks into meaningful pedagogical practice. This would need an examination and adaptation of curricula in HE and CFE for the vertical and horizontal integration of AIL across the curriculum and didactic, context-specific AIL-related training for educators in both fields (Łodzikowski et al. 2024; Mah et al. 2023), of which students could profit. In CFE contexts, where learners often bring diverse professional experiences and immediate application needs, learning designers could design flexible, modular teaching and learning formats that accommodate varied entry points and enable just-in-time learning aligned with workplace demands.

Further potential lies in sharpening and refining the terminology surrounding the field, clearly distinguishing the terms competencies, competence, skills, abilities and literacy in order to reduce misunderstandings, sharpen the constructs under investigation and thus make research results operationalizable for practical application in HE and CFE (Chiu et al. 2024).

On a pedagogical level, research on didactic approaches, learning design and educational technology should be expanded to identify which innovative and persistent formats are effective and which didactic value they bring to foster AIL of adult learners (Wannemacher, Bosse, and Lübcke 2025). Therefore, next to addressing the theoretical background and terminology of AIL in bespoke educational contexts, we call for broader and long-term empirical evaluations of learning designs and didactic approaches to enhance adult learners' AIL through higher, and perhaps even more pressing, continuing and further education.

Declaration of generative AI and AI-assisted technologies in the writing process

We used *Grammarly* to revise the grammar and improve the readability of the initial manuscript, which was written entirely without the aid of AI tools. After using the tool, we thoroughly examined and edited the suggestions and take full responsibility for the content of this article. Moreover, no AI application was employed in the process of data collection, data extraction, or data synthesis.

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* Indicates that these publications are included in the review corpus. The complete list of included studies can be found at <https://osf.io/5pv9b/>.

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Appendix A

Category	Studies	Description
AI literacy as competencies, skills, and/or abilities related to everyday life	Dai et al. (2020); Su and Zhong (2022); Leichtmann et al. (2023); Laupichler et al. (2022a); Kaspersen et al. (2022); Fyfe (2023); Chen et al. (2024); Crabtree (2023); Druga et al. (2019); Hervieux and Wheatley (2024); Laupichler et al. (2023b); Lee et al. (2024); Miao et al. (2021); Neyland (2019); Su et al. (2023); Tenberga and Daniela (2024); UNESCO (2022); Yang (2022); Yi (2021)	AIL as a prerequisite for successful everyday life: literacy is meant in the true sense of the word. Its absence is seen as a significant handicap to understanding the world in which we live.
AI literacy as a prerequisite for (future) success in the labour market, as well as competencies, skills, and/or abilities related to one's profession	Cardon et al. (2023); Cetindamar et al. (2024); Chan and Colloton (2024); Chauncey and McKenna (2023); Eguchi et al. (2021); Faruqe et al. (2021); Fourtané (2023); Tuomi et al. (2018); Kennedy (2023); Knoth et al. (2024); Lee et al. (2021); Lee et al. (2024); Lo (2024); Low et al. (2025); Moundridou et al. (2024); Southworth et al. (2023); Talagala (2021); Tenberga and Daniela (2024); UNESCO (2022); Wiljer and Hakim (2019); Williams et al. (2023); Wijaya et al. (2024); Xie et al. (2023); Zhai and Nehm (2023); Zhang et al. (2023); Zhao et al. (2022)	Studies link AIL to (future) employment or competitive advantages in the labour market. Competencies, abilities and/or skills related to working with AI need to be developed through concrete activities, applications, and examples concerning practical application.

Category	Studies	Description
AI literacy as (part of) a broad structure of proficiencies, knowledge, competencies, abilities, and/or skills	Ng et al. (2023); Long et al. (2021); Long and Magerko (2020); Wiljer and Hakim (2019); Carolus et al. (2023); Wienrich and Carolus (2021); Abulibdeh et al. (2024); Ayanwale et al. (2024); Abdelghani et al. (2023); AI4K12 Initiative (2025); Allen & Kendou (2024); Almasri (2024); Bozkurt (2023, 2024); Carter et al. (2020); Casal-Otero et al. (2023); Černý (2024); Chai et al. (2020); Chan and Colloton (2024); Cui and Wheatcroft (2021); Crabtree (2023); Dai et al. (2020); Ding et al. (2024); Hancock et al. (2020); Heyder and Posegga (2021); Hornberger et al. (2023); Ismaili (2024); Igbowke (2023); Kaledio et al. (2024); Kang (2023); Kennedy (2023); Kim et al. (2021); Knoth et al. (2024); Kong and Zhang (2021); Kong et al. (2023); Kong, Cheung, and Tsang (2023); Kong et al. (2024); Laupichler et al. (2023b); Laupichler et al. (2022a); Lee et al. (2024); Lei et al. (2021); Li et al. (2025); Liu et al. (2023); Lo (2024); Miao et al. (2021); Miao and Holmes (2021); Ndungu (2024); Olari (2023); Perchik et al. (2023); Pinski and Benlian (2024); Soto-Sanfiel et al. (2025); Sperling et al. (2024); Steinbauer et al. (2021); Stolpe and Hallström (2024); Su et al. (2022); Su et al. (2023); Tenberga and Daniela (2024); Touretzky et al. (2019); UNESCO (2022); Vuorikari et al. (2022); Wang and Lu (2023); Wang et al. (2023); Wienrich and Carolus (2021); Williams (2023); Wilton et al. (2022); Xiao et al. (2024); Yi (2021)	AIL as part of a broader field of competencies, abilities, and skills from which it emerges or in which it is constituted. The construct cannot be considered in isolation, as it is always part of a specific structural arrangement with other technological literacies, skills, knowledge, competencies and attitudes, as well as the context in which they are fostered. Moreover, AIL comprises cognitive and/or affective dimensions.
AI literacy as a composite structure of knowledge, competencies, abilities, and/or skills related to Bloom's (revised) taxonomy (Bloom et al. 1969; Anderson and Krathwohl 2006)	Ng et al. (2021a, 2021b, 2022a, 2022b); Ng and Chu (2021); Kong (2014); Southworth et al. (2023); Chen and Lin (2024); Alexandre et al. (2021); Ayanwale et al. (2024); Celik (2023); Cuomo et al. (2022); Han and Zhang (2025); Hennig and Pfeiffer (2023); Hervieux and Wheatley (2024); Hibbert et al. (2024); Hossain (2023); Hossain et al. (2025); Miao and Holmes (2021); Salhab (2024); Schiavo et al. (2024); Southworth et al. (2023); UNESCO (2024); C. Wang et al. (2025); Wang et al. (2023); K. Wang et al. (2025); Wong et al. (2020); Xie et al. (2023); Zhang et al. (2023); Carolus et al. (2023); Zhao et al. (2022)	Definitions of AIL that rely on the works of Ng et al. (2021a, 2021b) and Bloom's Taxonomy (1956), who define the construct as a set of four components: (1) knowledge and understanding of AI; (2) use and application of AI; (3) creation and evaluation of AI tools; and (4) AI and ethics, or in another, reduced or analogous composite structure

Category	Studies	Description
AI literacy as a form of (socio-) technological knowledge, abilities, skills, and/or competencies	Chen and Lin (2024); Lin et al. (2021); Mertala et al. (2022); Adams et al. (2023); Agustin et al. (2020); Alamäki et al. (2024); Burgsteiner et al. (2016); Chiu et al. (2024); Chiu and Sanusi (2024); Kang (2023); Kandlhofer et al. (2016); Kong et al. (2021); Kong, Abelson and Kwok (2022); Kong et al. (2022); Kong et al. (2024); Laupichler et al. (2023a); Laupichler et al. (2023b); Lee et al. (2021); Long et al. (2021); Wang and Lester (2023); Perchik et al. (2023); Pinski and Benlian (2023); Shapiro et al. (2018); Stolpe and Hallström (2024); Weber et al. (2023); Xu et al. (2021);	AIL is primarily (though not exclusively) associated with understanding the technical means of AI, including using and implementing AI in various ways to solve problems and tasks. Thus, sufficient technical and computer science education is regarded as essential. This knowledge can be utilised to assess the societal impact of AI or to tackle real-world issues with AI.
GenAI literacy	AACSB (2025); Annapureddy et al. (2025); Ou et al. (2024); Dwivedi et al. (2023); Hönigsberg et al. (2024, 2025); Hwang et al. (2023); Ramos and Condotta (2024); C. Wang et al. (2025)	GenAIL as a set of distinct, multidimensional competencies, skills and/or abilities in interacting with, (ethically) using, and evaluating GenAI and its output; the construct is often perceived from a technological perspective. Examples include prompt engineering, task allocation or instant feedback utilisation (Hönigsberg et al. 2025).
Socio-cultural AI literacy	Eguchi et al. (2021); Heyder and Posegga (2021); Kong and Zhang (2021); Kong et al. (2021); Kong, Cheung, and Tsang (2023); Kong et al. (2024); Wang and Lester (2023); Voulgari et al. (2022); Yi (2021)	AI literacy as skills, competencies, and/or abilities that are embedded in an individual's or a group's socio-cultural background and context. Another aspect relates to AI usage for problem-solving on a societal level
Critical and/ or responsible AI literacy	Bali (2023); Carolus et al. (2023); Deranty and Corbin (2024); Eguchi et al. (2021); European Commission: Directorate-General for Education, Youth, Sport and Culture (2022); Domínguez Figaredo and Stoyanovich (2023); Han and Zhang (2025); Henry et al. (2021); Hermann (2022); Heyder and Posegga (2021); Huang et al. (2024); Laupichler et al. (2022a); Laupichler et al. (2023b); Lee et al. (2021); Lee et al. (2024); Ndungu (2024); Nguyen et al. (2023); Osasona et al. (2024); Ou et al. (2024); Strauß (2021); UNESCO (2022); UNESCO (2024); Voulgari et al. (2022); Wang and Lu (2023); C. Wang and Wang (2025); Williams and Ingleby (2024)	Definitions with a pronounced focus on viewing AI, as well as the competencies, abilities, or skills related to AI literacy through a critical and/or responsible lens, including aspects like critical AI positionality, AI's societal impact, or responsible and ethical strategies for human-AI interactions

Category	Studies	Description
A posthumanist approach to AI literacy	Z. Wang and Wang (2025)	A «posthumanist approach to AI literacy does not frame AI literacy as an understanding of how human agents make and negotiate meaning with the help of AI; rather, it frames AI literacy as an understanding of how meaning emerges through human-AI intra-actions» (Z. Wang and Wang 2025, 3).

Tab. 3: Cluster of AIL understandings and definitions cited in the corpus, based on the work of Černý (2024, 5), but supplemented and expanded. Studies are occasionally sorted into multiple categories. One article cited in the corpus could not be found, two could not be retrieved (Zheng et al. 2021; Quan et al. 2023), and another was retracted by the editor-in-chief of the journal it was published in; therefore, they are not listed in the table.