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Artificial intelligence literacy in higher and adult education: A scoping literature review

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ABSTRACT

Since artificial intelligence (AI) is finding its way into more and more areas of everyday life, improving the AI skills of non-experts is important and will become even more relevant in the future. While it is necessary that children learn about the possibilities of AI at an early age, adults in higher education and beyond should also have at least a basic understanding of AI (i.e., AI literacy) to be able to interact effectively with the technology. To evaluate the current state of the literature on AI literacy in higher and adult education, a scoping literature review was conducted with the objective of identifying thematic foci and recent research trends. Ten research databases were searched and out of 902 initial records, 30 studies were identified using predefined eligibility criteria, whereof the content was evaluated in the review. The results indicated that research in this area is still in its infancy and needs refinement in terms of how to define AI literacy in adult education as well as what content should be taught to non-experts. Lastly, several recommendations for research and practice are derived from the results.

1. Introduction

1.1. Defining AI literacy

Artificial intelligence (AI) is permeating more and more areas of daily life, and is increasingly being used in professional context such as education (Chen et al., 2020; Hwang et al., 2020), healthcare delivery (Matheny, Whicher, & Israni, 2020; Noorbakhsh-Sabet et al., 2019; Maddox, Rumsfeld, & Payne, 2019), or marketing (Vlačić, Corbo, Costa e Silva, & Dabić, 2021; Verma, Sharma, Deb, & Maitra, 2021), to name just a few examples. Accordingly, the training of competencies in the field of artificial intelligence is extremely relevant not only for future artificial intelligence professionals, but also for people who are not computer scientists, mathematicians or AI engineers themselves, since they will have to interact with these new technologies on a daily basis.

The ability to understand, use, monitor, and critically reflect on AI applications without necessarily being able to develop AI models themselves is commonly referred to as being "AI literate" (Long et al., 2021; Ng et al., 2021a). To the best of our knowledge, the term was first used in an online article in 2015 (Konishi, 2015) and was picked up in an empirical article shortly afterwards (Kandlhofer et al., 2016). The term joins a long line of proposed literacies intended to symbolize the understanding of a particular technological construct, e.g., "digital literacy" (Gilster, 1997), "media literacy" (Livingstone, 2004), or more recently "data literacy" (Wolff et al., 2016). "AI literacy" encompasses AI competencies that the general population should possess and accordingly focuses mainly on learners without a computer science background ("non-experts"). A frequently cited definition of AI literacy was developed by Long and Magerko (2020, p. 2), who define it as "a set of competencies that enables 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".

1.2. Overview of AI literacy programs and related literature

Fostering AI literacy is being approached from many different angles. For example, there are initiatives to promote AI literacy already during school. This is illustrated, for example, by initiatives such as "AI4K12" (https://ai4k12.org/), or by journal articles reporting on AI teaching projects (Lee et al., 2021; Ng et al., 2022; Williams, 2021) or AI curricula (Touretzky et al., 2019) in primary/secondary schools.

In addition, many governments have recognized the need for AI literacy programs in higher and adult education as well. Thus, AI strategies have been published and distributed by the United States (National

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Artificial Intelligence Initiative Office (NAIIO), 2021), China (PRC Ministry of Education (教育部), 2019), and Germany (Federal Ministry of Education and Research (BMBF), 2021). There are also government-supported pilot programs such as "Elements of AI" (https://www.elementsofai.com/) from Finland, which aim to strengthen AI literacy for non-experts.

In addition, there have been a few projects in recent years that have attempted to introduce AI to college or university students. These projects particularly focused on students who came from non-IT backgrounds, such as medicine (Aulenkamp, Mikuteit, Löffler, & Schmidt, 2021; Brouillette, 2019; Charow et al., 2021), business administration (Xu & Babaian, 2021), or teacher education (Vazhayil et al., 2019). As mentioned before, increasing AI skills among "non-experts" is often considered as important as training AI experts, since this group will most likely use AI or collaborate and co-exist with AI (Ng et al., 2021a). Accordingly, basic AI literacy education focuses on understanding AI and critically reflecting on AI outcomes. Programming skills or computer science knowledge are not usually considered learning objectives of AI literacy, nor required qualifications (Long & Magerko, 2020).

Although all of these initiatives tend to share some common ground, structural and content-related differences still remain. There are various reasons for this, but the different target groups pose the main difference. For example, one characteristic of AI courses designed for non-experts is that they are commonly presented in short, easily digestible modules. In addition, they mostly rely on decentralized, digitally available instructional courses or learning materials (e.g., AI campus, https://ki-campus.org; Elements of AI, https://www.elementsofai.com/). AI education for schoolchildren, on the other hand, is often developed in a strongly hands-on and project-based manner. This is particularly true for younger children, who are not yet familiar with abstract explanations or the required mathematical foundations, thus requiring AI curricula that differ from those meant to address adults (Yang, 2022). Programs to increase AI literacy in adult education are often based at colleges or universities and often seem to address students' specific professional requirements. The efforts to increase AI literacy in children or the general population, however, are more often designed to provide a basic understanding of AI without placing the focus on a particular subject area.

A preliminary attempt to structure the heterogeneous research landscape described above has revealed that there are two main types of publications. The first describes courses that are intended to teach AI to non-experts in different ways (Lin et al., 2021; Shih et al., 2021). Here, the focus is often on course design and evaluation. The second stream of publications is more theoretical and provides definitions (Long & Magerko, 2020) or tries to explain how AI literacy relates to other literacy concepts (Kandlhofer et al., 2016; Wienrich & Carolus, 2021). Both types of publications are equally important to explore this topic. The former helps practically oriented researchers and teachers to identify "best practices", and to gather ideas for their own creation of teaching formats. The more theoretical literature, on the other hand, is essential for creating a clear understanding of AI literacy so that references to other fields can be made while also guaranteeing a clear distinction from similar but fundamentally different concepts. For this reason, both types of publications are described and critically reflected in this review.

1.3. Research motivation and aim

Although increasing AI literacy is a very important endeavor for the future, there is still relatively little empirical literature in this area. Nevertheless, a positive trend in publishing articles in this topic area is emerging, and more and more research teams around the world seem to be interested in exploring AI literacy (see Fig. 1). There have already been isolated attempts to sift through and evaluate the rather disorganized research literature by means of literature reviews (see Ng et al., 2021a). However, these reviews often focused on AI literacy in a more general sense (Ng et al., 2021a), or they concentrated on a selected variety of articles, for example to generate a universally valid definition of AI literacy (Long & Magerko, 2020). While these efforts are very helpful in mapping the current state of the research and further sharpening the construct of AI literacy, to the best of our knowledge, a closer look at the AI literacy of individual target groups through literature analysis is still lacking. However, this target-group-specific view is necessary to account for the differences in educational projects. Thus, in this paper, we will present a literature review for one of these target groups, namely AI learners in higher and adult education. For this group of people enhancing their AI literacy is crucial, since they are (or soon will be) confronted with AI applications not only in their daily but also in their professional life. They need to be able to collaborate and cooperate with AI in order to stay up to date and avoid being left behind in a fast-changing workplace. This is especially relevant for people who did not grow up as "digital natives" (Bennett et al., 2008).

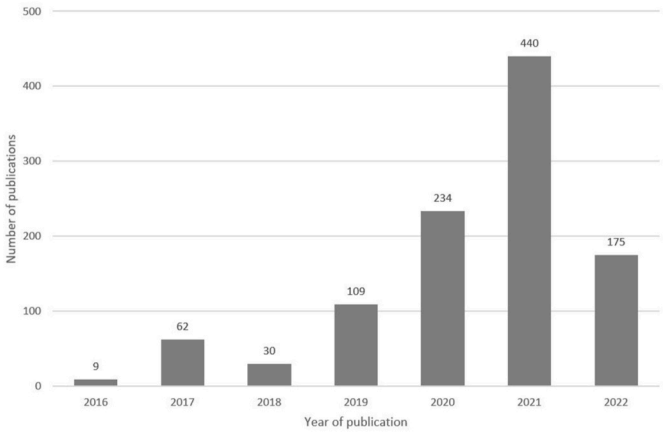

Fig. 1. Frequency of results on Google Scholar with the search term "ai literacy" OR "artificial intelligence literacy" for each year since 2016. Note: The search was conducted in May 2022, which is the reason for the smaller number of results in 2022 compared to 2021.

1.4. Research questions

We have proposed several research questions, the answers to which will help shed light on important aspects of AI literacy in higher and adult education. The first step is to examine if and to what extent certain topics, issues, or problems occur frequently in the literature. Therefore, our first research question is:

RQ 1: Which thematic foci can be identified in the literature on AI literacy in higher and adult education?

Furthermore, it is of great interest for future research to develop an understanding of AI literacy that is as universally applicable as it is useful. Therefore, research question 2 takes a closer look at how the included reports define the construct of AI literacy and how AI literacy is distinguished from related constructs, for instance, "AI readiness" proposed by Karaca et al. (2021) or "AI capabilities" (Markauskaite et al., 2022).

RQ 2: How does the literature on AI literacy in higher and adult education define the concept of AI literacy and how is it distinguished from related constructs?

AI literacy is a field of research that is being investigated interdisciplinarily. In order to develop a profound understanding of which disciplines are currently working on this topic and which groups are targeted in attempts to increase AI literacy, we have formulated research

question 3.

RQ 3.1: What professional disciplines are currently engaged in fostering AI literacy?
RQ 3.2: Which target groups are addressed by the publications in the field of AI literacy in higher and adult education?

As mentioned earlier, we did not focus explicitly on evaluating courses in AI education, but placed the focus of the review on AI literacy articles. Nevertheless, there are several articles, especially in recent years, which deal with the creation and evaluation of AI courses and present this in the context of current developments in the field of AI literacy education. Research question 4 therefore aims to provide a brief overview of teaching opportunities for increasing AI literacy in adults.

RQ 4.1: What teaching formats and pedagogical structures are used in courses that have the goal to increase AI literacy in higher and adult education?
RQ 4.2: What kind of content are these courses trying to teach and what lessons can be learned?

2. Methods

2.1. Exploratory literature review

Research on AI literacy is still in its infancy and literature on the topic is scarce. Therefore, the review process does not lend itself to meta-analyses or systematic literature reviews, which require a vast number of relatively homogenous publications to enable the conclusion of valid statements. Accordingly, we decided to follow a scoping literature review approach in order to focus less on statistical parameters and more on the content of the papers. We have followed the PRISMA statement on scoping reviews (Tricco et al., 2018) wherever feasible to ensure that the approach is as methodologically sound as possible.

2.2. Eligibility criteria

We developed seven exclusion criteria that were used in both the screening of the abstracts and the screening of the full-text reports (see Table 1). We excluded reports that mention the term AI literacy but have another focus (criterion 1), e.g., reports that focus on computational literacy (Jacob & Warschauer, 2018). As described in section 1.2, reports that cover AI literacy in the school context or in relation to childhood education (outside of school) were not of interest, which is why we excluded reports that focused solely on those target groups (criteria 2 and 3). We also excluded reports that referred to other forms of literacy, especially alphabetic literacy (i.e., reading and writing literacy, criterion 4). Since we have tried to conduct an exhaustive literature search, we have also gone through databases that do not exclusively contain scientific articles. Non-empirical reports (e.g., magazine or newspaper articles) were excluded in the screening process (criterion 5). Since artificial intelligence changed a lot in recent years, especially in comparison to AI methods from the last millennium (Anyoha, 2017; Council of Europe, 2022), we excluded reports that were published before 2000 (criterion 6). However, this does not pose a problem to the question at hand, as research on AI literacy has only been pursued for a few years (see Fig. 1) and the 70 records that were excluded solely on the basis of their year of publication did not deal with AI, but coincidentally included the suffix "-ai" followed by the word "literacy".[1] Lastly, we excluded reports written in a language other than English or German because the authors had a good command of only these two languages and otherwise there would have been a loss of information due to translation errors (criterion 7).

Table 1
Exclusion criteria.

Criterion number	Criterion name	Criterion explanation
1	Missing focus on AI literacy	Reports in which the term "AI literacy" is mentioned somewhere in the report, but which have a completely different focus
2	School education	Reports focused solely on AI literacy in school students (e.g., elementary schools, K-12 education)
3	AI literacy for children	Reports that focus on fostering AI literacy in children outside the school context (e.g., museum exhibitions for children).
4	Other forms of literacy	Reports focused on alphabetical literacy (e.g., research on the use of AI in promoting reading & writing abilities) or other forms of "literacy" that are not similar to AI literacy (e.g., computational literacy)
5	Non-empirical reports	Reports published in non-scientific media (e.g., newspapers, magazines)
6	Before 2000	Reports published before 2000
7	Foreign language	Reports published in languages other than English or German

2.3. Search strategy

We searched the following research literature databases: PubMed (National Library of Medicine), Web of Science (Clarivate), JSTOR (ITHAKA), ERIC (Institute of Education Sciences), IEEE Xplore (IEEE), PsycINFO (American Psychological Association), ACM Digital Library (Association for Computing Machinery), and ScienceDirect (Elsevier). Since we have placed great emphasis on capturing the latest developments in the research literature, and due to the novelty of the research topic, we have decided to include gray literature, as long as it meets basic scientific requirements. This includes, for example, master's theses, dissertations, and manuscripts that have not (yet) been published in a peer-reviewed journal. Thus, the extensive literature search engine of the "University and State Library Bonn" (Universitäts-und Landesbibliothek Bonn, https://www.ulb.uni-bonn.de/de/literatursuche/suchinstrumente/bonnus?set_language=en) was used, which includes preprint and gray literature databases such as arXiv.org in addition to traditional academic journals and databases. We conducted the initial search on November 30th, 2021, and an additional search on May 5th, 2022. The second search yielded an additional 43 records that were published between December 2021 and May 2022. Please refer to Fig. 2 for a more detailed breakdown of the number of records retrieved from the respective databases.

As mentioned earlier, the amount of literature regarding AI literacy is still relatively small, and this is especially true for literature on AI literacy in higher and adult education. Therefore, in the context of the research presented here, we drew an exhaustive picture of the existing literature. We will focus exclusively on articles that contain the term "AI literacy" or "artificial intelligence literacy" (Boolean conjunction: "ai literacy" OR "artificial intelligence literacy") in the title, abstract, or main text. Papers that dealt with the use of AI applications in educational contexts (commonly referred to as AIED, see International Journal of AIED, Kay & Aleven, 2022) or reports that focus on aspects of machine learning were beyond the scope of this review. Thus, we did not include terms like "AI education" or "learning artificial intelligence" as search terms, contrary to the approach of other authors (see for example Long & Magerko, 2020). We only sought to include research that explicitly deals with theoretical or practical aspects of AI literacy, i.e., teaching AI skills to non-experts. We did not set any further search restrictions and excluded inappropriate articles according to the exclusion criteria (see Table 1).

[1] To give an example: In an article by Graham (1989) on media literacy, the term "critical literacy" appears, which was apparently interpreted as " … ai literacy" by the optical character recognition system of one of the data bases.

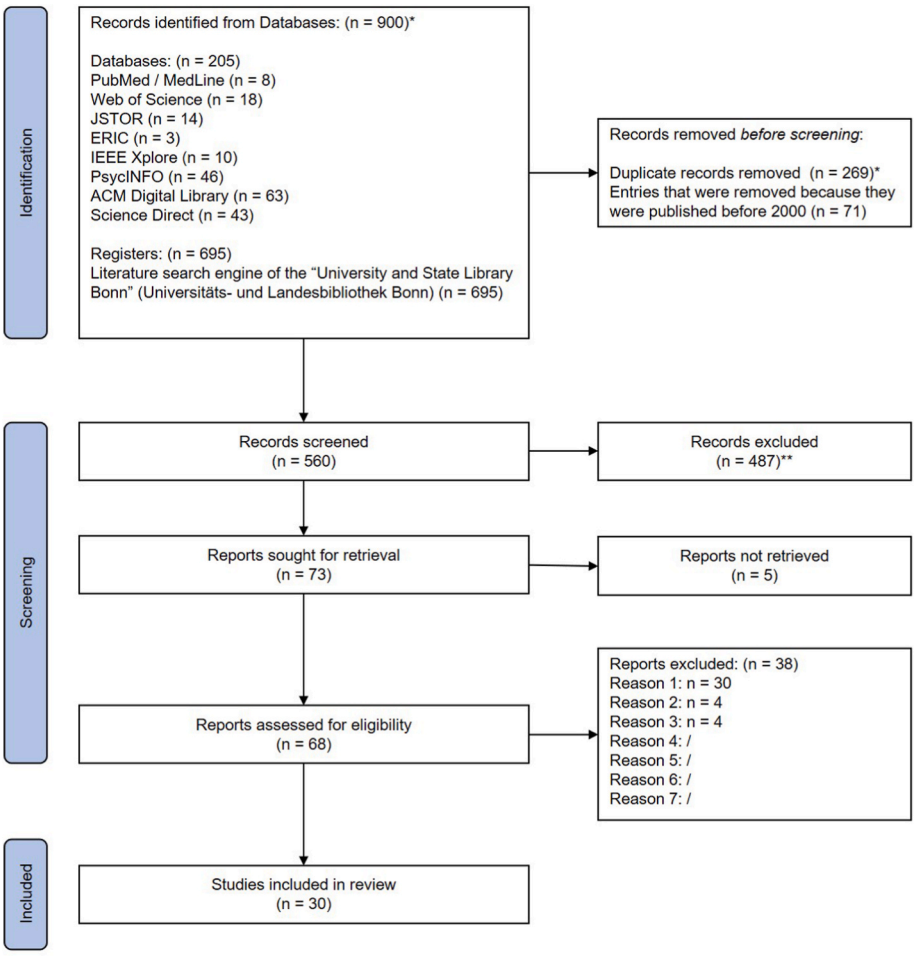

Fig. 2. Flow diagram of the review results, based on the reporting recommendations provided by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Note: The figure is adapted from Page et al. (2021) and was slightly modified since we did not use other means of study identification than databases and registers.

2.4. Review strategy

The decision-making process consisted of two successive stages. In stage one, we used Rayyan (Ouzzani et al., 2016; rayyan.ai), a web application designed to help with organizing and conducting literature reviews. We downloaded the results of all databases and registers, including title, abstract, and bibliographic information and uploaded the resulting files in Rayyan. Afterwards, two authors (MCL and AA) independently rated each report according to the exclusion criteria in a blind-rating process. After all abstracts had been rated, the blind-mode was lifted and disagreements were discussed and resolved in a systematic discussion. In stage 2, we sought to retrieve all reports whose titles and abstracts did not indicate that the exclusion criteria applied. The two authors mentioned above (MCL and AA) independently read the remaining reports in their entirety and checked them against the exclusion criteria. The decisions were then compared with each other. Inter-rater reliability, expressed as Cohen's kappa, was $\kappa = 0.62$, which can be interpreted as substantial agreement (Landis & Koch, 1977). In the event of differing assessments, a third independent member of the research team (JS) was consulted, to help resolving conflicts as a moderator. Additionally, a thorough scan of the reference lists of all included articles did not yield any additional results that could be considered for inclusion in our review.

A data charting table was developed to extract relevant content from the studies. The table was filled out independently by two authors (MCL and AA) and the entries were subsequently compared and adjusted as necessary. Besides bibliographical information, the table contained a short summary of the study, questions, statements, and arguments made about AI literacy in the study, the type of publication, the main target group, and if the study focused on a course to foster AI literacy. If the latter was true, then we also assessed the learning format, pedagogical structure, content, and evaluation method of the course, as well as the results of the evaluation.

Due to the relatively small number of included papers and the high heterogeneity, we did not calculate statistical values. However, we report the frequency of the different subclasses, e.g., how many studies came from which academic discipline.

3. Results

3.1. Selection of sources of evidence

As can be seen in Fig. 2, the initial search yielded 900 entries. The literature management program, Rayyan, automatically identified 269 (30%) entries as duplicates. The duplicates were subsequently reviewed and removed by an author (MCL). After the exclusion of 71 (8%) records

published before 2000, we were left with 560 (62%) records, whose abstracts were subsequently screened. One or more of the exclusion criteria could be identified in 487 records. The remaining 73 (8%) reports were sought for retrieval. This was successful for 68 reports, which were then assessed for eligibility. Ultimately, after a thorough review of the reports, 30 (3%) studies were chosen to be included in the review. Please refer to Fig. 2 for an overview of the frequency distribution of reasons for exclusion.

3.2. Year of publication and country of origin

A vast majority of the research concerned with AI literacy in higher and adult education was published in the last few years. In fact, 22 (73%) of studies included in the review were published in 2021 and the first few months of 2022 (see Table 2). This illustrates once again the topicality of and increasing research interest in AI literacy. If this trend continues in the future, it can be expected that the number of existing articles will have doubled again at the end of the year 2022.

Regarding the origin of the papers, one can identify three clusters: Research stemming from North America (13 studies, 43%), East Asia (10 studies, 33%), and "others" (7 studies, 23%). The United States of America and Canada make up for 43% of all research published in this field (Charow et al., 2021; Faruqe et al., 2021; Lee et al., 2022; Long & Magerko, 2020; McCoy et al., 2020; Pucchio et al., 2021; Register & Ko, 2020; Teng et al., 2022; Vazhayil et al., 2019; Wiljer et al., 2021; Wiljer & Hakim, 2019; Wood et al., 2021; Xu & Babaian, 2021). In East Asia, research is mainly dominated by China (Kong et al., 2021; Liu & Xie, 2021; Ng et al., 2021a, 2021b) and other technophile states like Taiwan (Lin et al., 2021; Shih et al., 2021). South Korea (Lee, 2021a, 2021b; Park & Suh, 2021) is also particularly noteworthy here, since it has published a larger number of articles on this topic, albeit all in Korean. Only three articles from Korea were published in English. In the "others" group, a research group from the University of Technology in Sydney and the University of Sydney in Australia published two studies on AI literacy in higher and adult education in 2021 and 2022. Accordingly, it might be worthwhile to keep track of these researcher groups' efforts.

Accordingly, it may be interesting to continue to follow developments in this area in the future.

Table 2
Absolute and relative frequency of various article characteristics.

Characteristics	Frequency	
Country of origin:		
USA	7	(23%)
Canada	6	(20%)
South Korea	3	(10%)
China	4	(14%)
Australia	2	(7%)
Taiwan	2	(7%)
Austria, Germany, India, Spain, Turkey, UK	Each 1 (3%)	
Publication Year:		
2022	4	(13%)
2021	18	(60%)
2020	5	(17%)
2019	2	(7%)
2016	1	(3%)
Study type:		
Curriculum/course description	11	(37%)
Review	7	(23%)
Empirical study	7	(23%)
Conceptual paper	5	(17%)
Academic/professional discipline:		
General Education	10	(33%)
Health Care	9	(30%)
Computer Science or Computer Science Education	5	(17%)
Economics & Business Administration	3	(10%)
Teacher Education	3	(10%)

3.3. Article type and academic disciplines

We found that articles mostly either described curricular developments (e.g., plans on how to structure curricula regarding AI literacy in university) or specific courses trying to foster AI literacy (11 studies, 37%; Lee et al., 2022; Lee, 2021a; Kandlhofer et al., 2016; Xu & Babaian, 2021; Park & Suh, 2021; Kong et al., 2021; Vazhayil et al., 2019; Rodríguez-García et al., 2020; Shih et al., 2021; Lin et al., 2021; Lee, 2021b). Seven studies (23%) also conducted (literature) reviews, either to define AI literacy and its core concepts (Long & Magerko, 2020; Ng et al., 2021a) or to compare existing AI literacy teaching programs in specific fields (e.g., health care) that have been published as research articles (Charow et al., 2021; Cetindamar et al., 2022). The research or review methods used differ in terms of their standardization, and only one study (Charow et al., 2021) follows PRISMA standards for review articles. Empirical papers exist, too, but differed widely in terms of objectives, scope, and research methods (7 studies, 23%). For example, there were attempts to examine what kind of information is best for lay people to understand AI and machine learning and make critical decisions based on this knowledge (e.g., Chiang & Yin, 2022; Register & Ko, 2020). As for research methods, three studies used surveys (Sit et al., 2020; Teng et al., 2022; Wood et al., 2021), two conducted an experiment (Chiang & Yin, 2022; Register & Ko, 2020), one reported on a semi-structured expert polylogue (Markauskaite et al., 2022), and one used self-assessment questionnaires to conduct factor analyses to create an AI readiness scale (Karaca et al., 2021). The five conceptual papers (17%) included in the review mainly stressed the relevance of fostering AI literacy in specific specialties like health care (e.g., McCoy et al., 2020; Pucchio et al., 2021; Wiljer & Hakim, 2019).

3.4. Research question 1: Recurring thematic foci in the literature on AI literacy in higher and adult education

We created two tables which allow detailed answers to all research questions mentioned in section 1.4 (see Tables 3 and 4), so for the sake of conciseness only a brief overview of the main findings is given in the following sections.

Most publications discussed some aspects regarding conceptual properties of AI literacy as a construct and tried to distinguish it from other, related theories or to combine it with them in a meaningful way. Eight studies (27%) specified particular skills or competency categories which are at the core of AI literacy (Cetindamar et al., 2022; Kong et al., 2021; Liu & Xie, 2021; Ng et al., 2021a; Ng et al., 2021b; Park & Suh, 2021; Register & Ko, 2020; Wiljer & Hakim, 2019) Mostly, three or four main components are distinguished which might overlap or contradict each other. For example, some authors postulated that programming skills are one of the main AI literacies (e.g., Liu & Xie, 2021), while others focused more on reflective and evaluative skills (e.g., Ng et al., 2021a). Moreover, many studies emphasized the relevance of AI literacy in higher and adult education (Lee, 2021a; Rodríguez-García et al., 2020; Sit et al., 2020; Xu & Babaian, 2021). One group of authors investigated a student population by conducting a survey and found that students already understand that AI literacy will be important in their professional lives and that they would like to see AI education integrated into their regular curriculum (Wood et al., 2021). Two groups of authors postulated the term AI literacy could not be clearly defined because it depends on the target group to which it is to be applied. Kandlhofer et al. (2016) found the complexity of AI literacy to be increasing along the different levels of education. Faruqe et al. (2021) claimed that the meaning and the scope of AI literacy depends on the frequency and intensity of use of AI technologies (i.e., people who are less frequently exposed to AI applications require lower AI literacy). In addition, two studies introduced constructs which are related to AI literacy but slightly differed from the original construct. Karaca et al. (2021) introduced the so-called "AI readiness", which describes the perceived preparedness of students for the use of AI in their professional life. Markauskaite et al.

Table 3
Characteristics of studies included in the review, including short summaries; questions, statements, and arguments about AI literacy; and target audience.

#	Title	First author	Year of publication	Short summary	Questions, statements, and arguments about AI literacy (if applicable)	Target group
1	Accelerating the appropriate adoption of artificial intelligence in health care: Protocol for a multistepped approach	Wiljer et al.	2021	Presents an elaborate research plan to accelerate the adoption of AI-enhanced medical care by focusing on mindsets, skillsets, and toolsets of point-of-care health providers and their leaders in the health system. Identifies 24 programs that seek to foster AI literacy among health care providers and analyzes common curricular themes.	No theoretical statements on AI literacy.	Health care providers and health care leaders (e.g., management)
2	Addressing AI and data literacy in teacher education: A review of existing educational frameworks	Olari & Romeike	2021	Examines the relationship between AI and data literacy competencies in existing educational frameworks. Proposes a preliminary approach to educate K-12 teachers that utilizes the data life cycle to reflect on data competencies relevant to AI.	Postulates that "AI cannot be appropriately grasped without data literacy" (Olari & Romeike, 2021), and that competencies related to AI are intertwined with knowledge and skills related to data.	K-12 Teachers
3	AI book club: An innovative professional development model for AI education	Lee et al.	2022	Describes a professional development-project to foster AI literacy in teachers, enabling them to teach AI to their students. To achieve this, a "book club" was created where teachers were assigned readings. The information gained from the literature were discussed in the next session, along with potential issues or questions regarding pedagogical realization.	No theoretical statements on AI literacy.	(Computer science) Teachers
4	AI literacy: Definition, teaching, evaluation and ethical Issues	Ng et al.	2021 (a)	Reports on the results of an exploratory literature review in which the authors tried to answer four questions: 1. How do researchers define the term "AI literacy"? 2. How do educators help learners develop AI literacy? 3. How do researchers evaluate students' AI literacy skills? 4. What are the ethical concerns in the domain of AI literacy?	Identifies four categories that are important for fostering AI literacy: 1. know and understand 2. use 3. evaluate 4. ethical issues.	Education leaders & AI literacy researchers
5	AI quality cultivation and application ability training for normal university students	Liu & Xie	2021	Calls for AI literacy training for "normal university students" which includes strengthening digital literacy, computational thinking, and programming abilities. Provides an AI literacy framework & AI literacy training strategy.	Postulates that AI literacy consists of three main aspects: 1. digital literacy 2. computational thinking 3. programming abilities	"Normal university students" (e.g., students becoming teachers in China)
6	Analyzing the effects of AI education program based on AI tools	Lee	2021 (a)	Describes the creation of an AI literacy course for non-IT-majors in a Korean university. The evaluation of the results showed that the course fostered AI literacy on three different dimensions: 1. Understanding AI, 2. AI ethics, 3. Efficacy towards the utilization of AI	States that a lot of research about AI literacy focuses on school education, although it is equally as important to strengthen the AI literacy of non-IT-majors in college and university.	Non-major undergraduate students (e.g., liberal arts & humanities students)
7	Are we ready to integrate artificial intelligence literacy into medical school curriculum: Students and faculty survey	Wood et al.	2021	Compares the attitudes towards AI literacy of medical faculty to medical students. Overall, each group finds AI to be an exciting and promising new technology. Major differences are rare and basically limited to the self-assessment of having a basic understanding of AI (students rank higher) and the attitude towards AI-training topics.	Observes that medical students as well as faculty find AI literacy training important and think that AI education should be included in medical curricula.	Medical students and faculty
8			2016			

(*continued on next page*)

Table 3 (*continued*)

#	Title	First author	Year of publication	Short summary	Questions, statements, and arguments about AI literacy (if applicable)	Target group
	Artificial intelligence and computer science in education: From kindergarten to university	Kandlhofer et al.		The first empirical publication that uses the term AI literacy. Provides a curriculum-framework structured according to different school levels (i.e., kindergarten to university) which stands in relation to classical reading/ writing literacy. Lists pilot projects that implemented these curricula.	Postulates that AI literacy has similarities to classical reading/ writing literacy and consists of the following aspects: Automata, intelligent agents, graphs and data structures, basics of computer science, sorting, problem solving by search, classic planning, machine learning. Similar to classical literacy-development, the complexity of AI constructs and topics increases along the education levels.	Everyone (primarily researchers and teachers)
9	Artificial intelligence education programs for health care professionals: Scoping review	Charow et al.	2021	Presents the results of a scoping literature review which was conducted to provide an overview over AI education programs that were specifically designed to foster AI literacy in health care professionals. Finds and analyzes 41 studies which either describe AI courses or discuss AI curricula development.	No theoretical statements on AI literacy.	Medicine students and faculty
10	Artificial intelligence in business curriculum: The pedagogy and learning outcomes	Xu & Babaian	2021	Presents new course curriculum which is meant to specifically cater to business students' needs. Describes challenges and lessons learned in developing an AI course for non-technical audiences (e.g., business students).	States that AI literacy education for non-STEM students is very relevant, but materials to teach AI to non-technical learners is still lacking.	Business students and faculty
11	A study on artificial intelligence education design for business major students	Park & Suh	2021	Uses the Delphi-method to assess how to generate and structure an AI literacy curriculum for business major students. The resulting curriculum is rather technical and includes aspects such as data visualization, web scraping and machine learning.	States that the "main competencies for cultivating AI literacy were data literacy, AI understanding and utilization" (Park & Suh, 2021) and lists "main detailed areas" (ibid) derived from the main competencies. In contrast to other courses/curricula, it does not include meta level aspects (like AI in general, history of AI, ethics, etc.).	AI literacy researchers
12	Attitudes and perceptions of UK medical students towards artificial intelligence and radiology: A multicentre survey	Sit et al.	2020	Evaluates the attitude of medical students towards AI. Finds that only a small fraction of the surveyed medical students receive any AI education. The results indicate that AI literacy training has a positive effect on the attitude towards AI and on the willingness to specialize in radiology.	While the study does mention AI literacy only once, it postulates that AI (literacy) training is essential for medical students, but that "the level of AI literacy amongst the UK medical student population remains unknown" (Sit et al., 2020).	Medical students and faculty
13	Competency model approach to AI literacy: Research-based path from initial framework to model	Faruqe et al.	2021	Provides a framework on how to conduct research on AI-literacy competencies, on how to assess them, foster them, and how this could affect policy making. Introduces 4 groups which are distinguished based on their member's exposure to AI.	Postulates that the meaning of AI literacy can vary according to the group of people that an initiative focuses on (e.g., consumers need a different level of AI understanding than creators of AI).	Focus on (AI-) educators and educational institutions
14	Conceptualizing AI literacy: An exploratory review	Ng et al.	2021 (b)	Some similarities with Ng et al. (2021a). Presents an exploratory review that analyzes 30 research papers on AI literacy according to 1. Definition of AI literacy 2. Learning artefacts, pedagogical approaches, subject matters 3. Evaluation of AI literacy skills 4. Ethical concerns in AI literacy	Finds that AI literacy can be divided into 4 components: 1. Know & understand 2. Use & apply 3. Evaluate & create 4. Ethics. Uses Bloom's taxonomy to structure AI literacy education on different levels (from "know" to "create").	AI literacy researchers
15	Developing an artificial intelligence–enabled health care practice: Rewiring health care professions for better care	Wiljer & Hakim	2019	Promotes fostering AI literacy for health care professionals. Points out strategies regarding change due to AI in personnel and organizations. Focuses on building capabilities in: 1. Data governance principles 2. Basic statistics and	Argues that the focus of AI education cannot be placed solely on the intricacies of coding and ML algorithms and should rather lie on extending the four aforementioned capabilities. States that AI technologies which have to be	Mainly medical students, faculty, and health care professionals

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Table 3 (*continued*)

#	Title	First author	Year of publication	Short summary	Questions, statements, and arguments about AI literacy (if applicable)	Target group
				algorithmic decision-making 3. Data visualization and storytelling capabilities 4. Impact on clinical processes.	understood by health care professionals "include expert systems, robotic process automation, natural language processing, machine learning, and deep learning" (Wiljer & Hakim, 2019).	
16	Evaluation of an artificial intelligence literacy course for university students with diverse study backgrounds	Kong et al.	2021	Describes the development and evaluation of an AI-course for university students with diverse study backgrounds. The authors created three scales to measure the success of the learning intervention. Found that the AI course was successful, decreasing differences in AI literacy between computer science majors and others.	Proposes that "AI literacy includes three components: AI concepts, using AI concepts for evaluation, and using AI concepts for understanding the real world through problem solving" and "that cultivating AI literacy is a way to equip educated citizens with the skills to advance their interests as members of society and to use AI to serve their communities" (Kong et al., 2021).	University students (from diverse study backgrounds)
17	Explicating AI Literacy of employees at digital workplaces	Cetindamar et al.	2022	Analyzes 270 articles through a bibliometric analysis approach to define AI literacy, especially in relation to employees' capabilities. Investigates what the existing literature says regarding employees' capabilities in AI literacy.	Finds "four sets of capabilities associated with AI literacy, namely technology-related, work-related, human-machine-related, and learning-related capabilities" (Cetindamar et al., 2022).	AI literacy researchers, managers & employees
18	Exploring the effects of machine learning literacy interventions on laypeople's reliance on machine learning models	Chiang & Yin	2022	Reports on the results of an experiment in which the authors used different instructional materials to inform participants about machine learning and the risks associated with it. The instructions differ on two dimensions: Interactivity (facts vs. own experience) and scope (general information about ML vs. information about the ML model used in the experiment). Found that short user tutorials can help people to rely on ML models more appropriately, especially when those people have a high ability in solving the decision tasks themselves.	Provides ideas regarding machine learning literacy, which comprises a large subfield of AI literacy. They do not focus on long-term AI literacy improvement, but rather on short term ML literacy interventions similar to "user guides" in cars.	Everyone (primarily scientific community, but also practitioners and ML-users)
19	Focusing on teacher education to introduce AI in schools: Perspectives and illustrative findings	Vazhayil et al.	2019	Describes the first implementation of a course created to teach Indian computer science teachers about AI and how to program own AI programs. The objective of the program was to enable teachers to replicate parts of the course at their own schools.	No theoretical statements on AI literacy.	Computer science teachers
20	Health care students' perspectives on artificial intelligence: Countrywide survey in canada	Teng et al.	2022	Presents the results of a survey of Canadian health care students (e.g., medical students, nurses) regarding their attitude and understanding of AI. Finds that the majority of students think that AI will have an influence on their jobs in the coming decade, and that most of the students (even those opposed to AI) find general AI literacy and programs to foster AI understanding important.	No theoretical statements on AI literacy.	Health care students and faculty
21	Introducing artificial intelligence fundamentals with LearningML: Artificial intelligence made easy	Rodríguez-García et al.	2020	Presents the "LearningML"-program, which consists of a web application, including a machine learning-editor and a machine learning-programming environment. While the program was initially developed to teach kids about machine learning, the authors state that it is also suitable	No theoretical statements on AI literacy, but postulates that "some kind of AI literacy is needed if we are to educate critically thinking citizens able to understand technologies that have a relevant impact on their lives." (Rodríguez-Garcìa et al., 2020).	Originally designed for children/adolescents but also applicable in undergraduate or professional education

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Table 3 (*continued*)

#	Title	First author	Year of publication	Short summary	Questions, statements, and arguments about AI literacy (if applicable)	Target group
				for AI-novices in undergraduate or professional education.		
22	Learning ethics in AI—Teaching non-engineering undergraduates through situated learning	Shih et al.	2021	Presents the organizational structure and the outcome of a *situated learning* AI-course for non-engineering students. Besides introductory information about AI, students who participated in the course had to train an AI model that was developed to autonomously steer a toy car.	States that AI ethics is becoming more important in AI literacy, especially for non-engineering students. Goes on to explain that "the development of literacy means not only the cultivation of knowledge and skills but also the formation and application of knowledge concepts in daily living" (Shih et al., 2021)	Students without an engineering background
23	Learning machine learning with personal data helps stakeholders ground advocacy arguments in model mechanics	Register & Ko	2020	Describes an experiment that was conducted to test different ways to foster "machine learning literacy" and the ability to ground advocacy arguments in model mechanics in non-experts. The experiment used three conditions to investigate if learners understand machine learning concepts best when they were taught through examples with the participants own data, the data of another individual, or simple facts.	Explains that core features of machine learning literacy "include model transparency, understanding the mechanisms, contextualizing data, critical thinking, and leveraging learners' interests and backgrounds" (Register & Ko, 2020), and postulates that "this literacy is not at the level of programming or innovating on the systems themselves, but it is more generalizable than simply knowing facts about ML systems" (ibid).	Students without prior data science or machine learning training
24	Medical students need artificial intelligence and machine learning training	Pucchio et al.	2021	States that AI becomes increasingly important in healthcare and will have an enormous influence on physicians and their professional role in health care delivery. Simultaneously, few medical schools offer AI education. Gives three recommendations on what to do to improve the status quo.	Postulates that "ML and AI Literacy should be the goal of education, not full proficiency" (Pucchio et al., 2021).	Medical students and faculty
25	Medical artificial intelligence readiness scale for medical students (MAIRS-MS) - Development, validity and reliability study	Karaca et al.	2021	Presents the development of a scale intended to measure medical "AI readiness", a construct with many similarities to "AI literacy". Generated items through literature search and expert opinions and proceeded to test 22 items on Turkish medical students. Conducted an exploratory and confirmatory factor analysis and found a 4-factor-structure, which they subsequently named: AI-cognition, -ability, -vision, and -ethics.	Describes AI readiness, a construct with many similarities to AI literacy. The authors define AI readiness as follows: "medical artificial intelligence readiness is the healthcare provider's preparedness state in knowledge, skills, and attitude to utilize healthcare-AI applications during delivering prevention, diagnosis, treatment, and rehabilitation services in amalgam with own professional knowledge" (Karaca et al., 2021).	Medical students and faculty
26	Rethinking the entwinement between artificial intelligence and human learning: What capabilities do learners need for a world with AI?	Markauskaite et al.	2022	Describes a polylogue about AI capabilities between experts from different (research) fields. During the semi-structured process, the authors wanted to investigate what capabilities are needed for AI, how they could be conceptualized and developed, and how this development could be evaluated. Finds capabilities in three domains: Cognitive, humanistic, and social.	Criticizes the term "AI literacy". Postulates that AI literacy only concentrates on knowledge or attitudes directly related to AI, although learners also need to foster pre-existing capabilities like cooperation or creativity "to develop for a world with AI" (Markauskaite et al., 2022). Promotes the use of "AI capabilities".	Everyone (i.e., no specific target group)
27	STEM based artificial intelligence learning in general education for non-engineering undergraduate students	Lin et al.	2021	Great resemblance to Shih et al. (2021). Presents the organizational structure and the outcome of an AI-course for non-engineering students	See Shih et al. (2021)	Students without an engineering background
28	The effect of artificial intelligence literacy education on university students' ethical consciousness of artificial intelligence	Lee	2021 (b)	Great resemblance to Lee, A. (2021a). Focuses on AI ethics. Found that their course on the principles of AI has a positive influence on AI ethics literacy, which they subdivided into 4 factors.	See Lee, A. (2021a)	Non-major undergraduate students

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Table 3 (*continued*)

#	Title	First author	Year of publication	Short summary	Questions, statements, and arguments about AI literacy (if applicable)	Target group
29	What do medical students actually need to know about artificial intelligence?	McCoy et al.	2020	Describes what medical students need to learn about AI, since AI is becoming more and more important in healthcare delivery. The authors draw on experiences in two influential medical schools and advocate for a dualistic approach combining curricular with extracurricular teaching and learning objectives.	Indirectly states that AI literacy (in medicine) consists of three aspects: 1. Using it (identifying when the technology is appropriate for a given context) 2. Interpreting the results 3. Explaining it (e.g., to colleagues or patients)	Medical students and faculty
30	What is AI literacy? Competencies and design considerations	Long & Magerko	2020	Presents the results of a scoping review on the existing literature regarding AI literacy. Provides a definition of AI literacy and proceeds to list 17 competencies which AI literate humans should possess. Furthermore, the authors list 15 aspects that should be considered by teachers and researchers designing courses to foster AI literacy.	Defines AI literacy as "a set of competencies that enables 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).	Everyone interested in AI literacy (e.g., AI literacy researchers, AI learners)

(2022) critically appraised the term AI literacy and argued that "AI capabilities" fits better, as the term describes that AI competencies are an extension of already existing competencies.

A word cloud generated based on the frequency of used keywords in the included studies revealed that most studies naturally used the keyword "education" and "artificial intelligence" as well as "AI literacy". Furthermore, according to the keywords, some studies seemed to focus thematically on the medical field and the application of AI in healthcare (e.g., "medical students'', "medical education", see Fig. 3). In addition, many publications used the keyword "artificial intelligence ethics''. Although the selected literature only contained studies that were largely concerned with AI literacy in higher and adult education, the key term "K-12″ appeared several times.

3.5. Research question 2: Definition and delineation of the AI literacy construct

Twenty-five of the thirty studies (83%) included in the review provided some type of assessment of what should (and should not) be considered part of AI literacy (e.g., Ng et al., 2021a, Ng et al., 2021b; Kong et al., 2021; Cetindamar et al., 2022). The first peer-reviewed publication that ever mentioned the term AI literacy compared the development of AI literacy with the development of the traditional reading/writing literacy, which is taught at a young age and becomes increasingly more complex and delicate in higher forms of education (e.g., university education, Kandlhofer et al., 2016). Most studies agreed in the opinion that AI literacy is less about programming or the intricacies of coding and machine learning algorithms (e.g., Pucchio et al., 2021; Register & Ko, 2020; Wiljer & Hakim, 2019), but at the same time "it is more generalizable than simply knowing facts about ML systems" (Register & Ko, 2020). In this regard, the article by Long and Magerko (2020) should be mentioned in particular. The definition developed by the two authors was cited and adopted in most of the studies listed in the review, and most authors used the definition or agreed with it at least in part. In fact, the seminal work was cited in 16 of the 24 (66%) papers included in the review that were published after Long & Magerko's publication (see section 1.2 for the full definition).

Some slightly deviating voices also became apparent. For example, Karaca et al. (2021) used the term "AI readiness", which has some overlaps with AI literacy, but is nevertheless different in its basic features (Karaca et al., 2021). Another group of researchers criticized the term AI literacy as being too specific and would rather use AI capabilities, as the latter term also includes general competencies that were important prior to the emergence of AI (e.g., "cooperation" or "complex problem-solving") and now take on a new meaning (Markauskaite et al., 2022).

3.6. Research question 3: Academic disciplines and target groups

As can be seen in Tables 2 and 3, general education (10 studies, 33%) and health care (9 studies, 30%) made up the largest percentage of publications in the research field. The target audience of the included studies depended on whether the article discussed curricula developments/courses or had a more theoretical base. In the former case, the target audience mostly consisted of teachers, students, and administrative staff in higher education. In the latter group of articles, the audience consisted of AI literacy researchers, or in some cases, the general public (i.e., everyone interested in the topic).

3.7. Research question 4: Courses fostering AI literacy

The courses fostering AI literacy in higher and adult education used various teaching formats and pedagogical structures (see Table 4). A main trend could not be identified, but some insights can nevertheless be derived. In terms of teaching formats, we found two courses (20% of all courses included in the review) taking a "flipped classroom" approach. During these courses, the students were asked to work through content about AI (e.g., in the form of books or online materials) outside of class and then work on projects or discuss implications of their newly acquired knowledge during class sessions (Bishop & Verleger, 2013, June). Another finding is that five courses (50%) provided access to some form of programming environment, whether in computer labs within institutions (e.g., Vazhayil et al., 2019) or in sandbox programming environments in the digital world (e.g., Rodríguez-García et al., 2020). The pedagogical structure of nine (90%) courses seemed to be a combination of knowledge transfer (e.g., through reading AI-literature or teaching about AI in lectures) and hands-on units. The hands-on units differ from one another in particular in the extent to which they encouraged students to learn programming. Some practically oriented units or exercises simply illustrated how the outcomes of AI depend on the underlying data (e.g., Shih et al., 2021), while others taught the actual programming of code for machine learning algorithms in, for example, Python (e.g., Xu & Babaian, 2021).

Regarding the learning content, most courses (7 studies, 70%) had

Table 4
Characteristics of studies that report on courses which were created to foster AI literacy, including teaching format, pedagogical structure, main content, and evaluation. Note: (11) also belongs to "Curriculum/Course description", but focuses on creating an AI literacy curriculum and does not report on an AI literacy course, which is why it is not included in this table.

#	Teaching format	Pedagogical structure	Main content	Evaluation & Assessment methods
3	Flipped Classroom (i.e., reading material at home and subsequent discussion in "class")	Mostly knowledge transfer through reading literature and discussing the information in class	1. What is AI? 2. Ethics in AI 3. Roots of AI (logic systems, decision trees) 4. Ethics in AI: Bias 5. Machine Learning 6. Neural Networks & Deep Learning 7. Generative AI	Course was evaluated in a mixed-method approach. Evaluated session attendance, participation in discussion forum, and teachers' opinions. Teachers assessed it positively and stated that they will include some aspects in their own teaching.
6	Not specified (but probably classroom learning)	Combination of knowledge transfer and hands-on learning (including some coding exercises)	1. Computational Thinking & Programming 2. Understanding AI 3. Practicing AI 4. Developing AI	Course was evaluated by quantitatively measuring the change in self-assessed AI literacy of students before and after taking part in the course. Found a significant improvement.
8	Different formats according to the age of the participants, e.g., course-based education for university students	Different pedagogical structure according to the age of the participants, e. g., a combination of knowledge transfer through textbooks and hands-on exercises for university students	Differing content, depending on educational level	Extensive preliminary evaluation (quantitatively and qualitatively). Preliminary results look promising, but the study does not go into great detail regarding evaluation results.
10	Formal classroom learning through lectures, plus additional demonstrations, case studies, in-class exercises, programming, assignments, and a term project	A combination of knowledge transfer (e.g., through lectures) and project-based learning (e.g., through programming assignments)	1. AI foundations and intelligent agents 2. Knowledge representation and probabilistic reasoning 3. Problem solving 4. Machine learning 5. Ethics	Course was evaluated quantitatively. Lectures and programming assignments were rated the highest. Content about ML and DL was perceived to be the most relevant. Caveat: Relatively small sample of n = 16.
16	Flipped Classroom	Knowledge transfer (through classroom lessons) and practical exercises (but no programming exercises)	First course in a series of three courses (1. ML 2. DL 3. Solving problems by developing AI solutions). This course focused on 1. Artificial Intelligence (Introduction) 2. Machine Learning 3. Supervised Learning 4. Unsupervised Learning	Course was evaluated quantitatively (self-assessment and test) and qualitatively (focus-group interviews). Found high learning outcomes. Differences in AI literacy between CS-majors and other students decreased. Gender differences were negligible, although the course helped to improve perceived AI empowerment in female participants, bringing them closer to the self-assessment of male participants.
19	Classroom learning (computer lab)	Knowledge transfer (e.g., through handouts and training videos) and hands-on learning (simple programming exercises in class)	Knowledge-transfer: theoretical concept of AI and difference between machine learning and deep learning, and weak and strong AI Hands-on learning: Several demonstrative learning activities to explain 1. Text recognition/ sentiment analysis 2. Image classification 3. Categorical/ Numerical data	Course was evaluated qualitatively. Found that teachers assessed the course rather positively. Found some cultural constraints that might hinder the implementation of the program in teacher's schools, e.g., schools think that internet access in computer labs might lead students to play games, go on forbidden websites, etc.
21	Online teaching (through website)	Knowledge transfer (e.g., through tutorial videos on website) and hands-on learning (model training and programming exercises)	Not clearly described in the article (but uses image recognition with machine learning as an example)	Preliminary conference paper. Did not evaluate the course (yet).
22	Classroom learning (computer & robotics lab)	Knowledge transfer and experimental, hands-on learning (e.g., exercises on the influence of data on AI performance). No programming exercises.	1. Lecture: Introduction to AI (with use cases) 2. Demonstration of training process 3. Training of model 4. Testing of model on car kit ("toy" car)	Course was evaluated quantitatively. Found a positive impact on students' understanding of and attitudes towards AI. Understanding of and attitudes towards AI

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Table 4 (*continued*)

#	Teaching format	Pedagogical structure	Main content	Evaluation & Assessment methods
				predicted the awareness of ethical issues regarding AI.
27	Classroom learning (computer & robotics lab) [a]	Knowledge transfer and experimental, hands-on learning (e.g., exercises on the influence of data on AI performance). No programming exercises.	1. Lecture: Introduction to AI (with use cases) 2. Demonstration of training process 3. Training of model 4. Testing of model on car kit ("toy" car)	Significant improvement of AI literacy according to the students' self-assessment (comparison between begin and end of the course).
28	Not specified (but potentially classroom learning) [b]	Mostly knowledge transfer through reading literature and discussing the information in class.	1. Computational Thinking & Programming 2. Understanding AI 3. Practicing AI 4. Developing AI	Course was evaluated by quantitatively measuring the change in self-assessed AI literacy of students before and after taking part in the course. Found a significant improvement.

[a] Describes the same or a very similar course as (22).
[b] Describes the same or a very similar course as (6).

one or several initial units that were meant to provide a first understanding of what AI is, where it came from, what it can and cannot do, etc. Those initial lessons had different names in the curricula, e.g. "What is AI?" (Lee et al., 2022), "AI foundations and intelligent agents" (Xu & Babaian, 2021), or "Artificial Intelligence (Introduction)" (Kong et al., 2021), but often covered similar topics. Most courses also talked about machine learning and deep learning, as they form the basis for most AI applications today (7 studies, 70%). Three courses (30%) also specifically focused on ethical issues in AI and attempt to address aspects such as algorithmic bias or "AI as a black box" (e.g., Lee et al., 2022; Xu & Babaian, 2021).

The quality of learning outcome assessment and course evaluations varied greatly, which is why no generally valid statements can yet be made on the basis of the small sample described here. Nevertheless, it seemed that students from non-expert subjects evaluated courses to increase AI literacy positively and recognized their benefits. While three studies (30%) compared AI literacy before beginning the course and after completing the course (e.g., Kong et al., 2021; Lee, 2021a), it was not always apparent what this measurement was based on. There is no reliable and valid measurement tool to capture AI literacy to date, and the evaluations done in the studies described here seemed to be based on self-created items and non-validated scales. However, based on the instruments used, it is possible to make at least the preliminary statement that the courses described here have increased the participants' AI literacy.

4. Discussion

4.1. Significance of the findings

We conducted a scoping literature review focused on AI literacy in higher and adult education. Exactly 900 abstracts were checked, of which 30 studies were found to be eligible for inclusion in the review. We analyzed the studies' content to answer four main research questions that were concerned with the identification of recurring thematic foci, the definition and delineation of the AI literacy concept, the investigation of academic disciplines working in the field of AI literacy in higher education, and the review of courses trying to foster AI literacy in adults.

In our review, we came to the same conclusion as Long & Magerko in their seminal AI literacy review (2020), in that AI is a relatively novel research field. However, while Long & Magerkos paper from 2020 states that most of the cited work "was just published in the last two years" (i.e., 2018–2020, p.10), most of the research discussed in our study stems from 2020 or later. This may indicate that research on AI literacy in higher and adult education lags behind research on AI education in other areas. A positive trend regarding the number of publications was observed. Increasing the amount of high-quality AI literacy research articles helps to fill the theoretical or practical knowledge gaps that were, for instance, identified by Ng et al. (2021a) and Cetindamar et al. (2022).

The USA and Asia published the most studies in this research area, which is somewhat unsurprising, as these regions are the major forces in AI technology development in general and "vie for leadership" in AI development (Savage, 2020, p. 1). However, institutions and researchers from Europe, Africa & South America should also investigate AI literacy to ensure quality AI education in these parts of the world. If the promotion of AI literacy in these parts of the world would be abandoned, ethical problems might arise. According to Hermann (2022), there is a "need of basic understanding of AI inputs, functioning, agency, and outcomes" (p.1) to ensure the ethical application of AI.

The quality of the studies assessed differed widely. Although the topic is new and hardly comparable to other educational fields that are

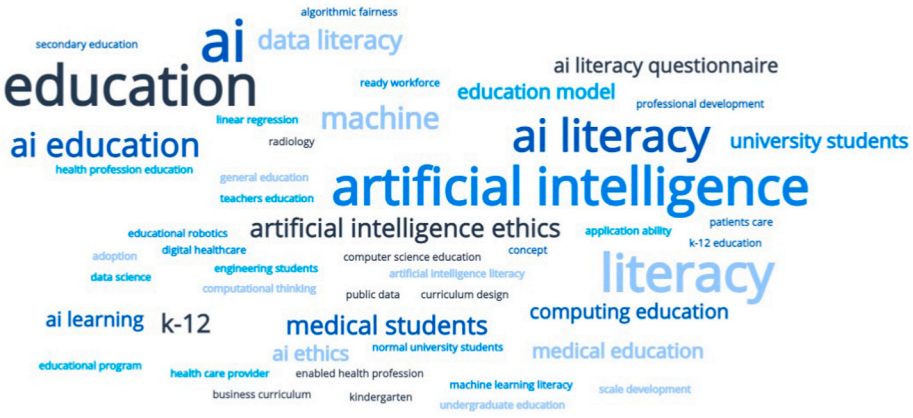

Fig. 3. Word cloud created by comparing the frequencies of the keywords used in the studies included in the review. Larger fonts indicate a more frequent use of the keyword.

evaluated thoroughly, research teams should stick to research methods that are of high quality and empirically validated. Additionally, it would be interesting to see more experiments like those conducted by Chiang and Yin (2022) or Register and Ko (2020) which compare certain aspects of AI literacy in an otherwise homogenous setting, since experiments can help to check even minor peculiarities and optimize them if necessary.

Answering research question 1 brought the conclusion that most studies focus on courses meant to foster AI literacy. Many teachers do not know how to structure AI courses (Vazhayil et al., 2019) or what content can be taught in an AI literacy course (Lee et al., 2022). Thus, enabling teachers to compare different existing educational frameworks might support the creation of new courses on AI. In addition, some authors direct the thematic focus to present competencies that they believe are at the core of AI literacy. The drawback is that the proposed AI competencies sometimes differ greatly between the studies. Research endeavors comparable to a recent OECD report on the demand of AI skills (Samek et al., 2021) should therefore find out what skills an individual needs to acquire in order to be AI literate.

As mentioned in section 3.5, the term AI literacy is not yet precisely defined. In our opinion, Long & Magerko's (2020) definition is the best fit for AI literacy in higher and adult education, as it combines the most important aspects of AI literacy definitions from other studies while simultaneously explaining that AI literacy is more about the usefulness of AI technology in everyday life than, for example, about the technological development of AI applications. Despite the introduction of interesting competing concepts such as "AI readiness" (Karaca et al., 2021) and "AI capabilities," (Markauskaite et al., 2022) the term "AI literacy" represents the underlying idea in the best way. The construct of "AI readiness" has a strong affective component that should not be the focus of AI literacy, as it is more about theoretical knowledge and practical skills. "AI capabilities" on the other hand, compared to AI literacy, represents a concept that cannot be well distinguished from related concepts. Ultimately, however, it must be noted that the endeavor of defining AI literacy is still ongoing. For further research in this area, it would be of great importance to agree on a general definition that is clear and unambiguous, and clearly distinguish it from other definitions.

Lastly, adequate educational programs should be made available to take advantage of AI technology (Yi, 2021). The review of the courses meant to promote AI literacy in higher education students and adults revealed that a combination of knowledge-transfer and hands-on units seems to work well in teaching AI competencies. However, half of the courses reviewed seem to use programming exercises, which goes against the assumption of Long and Magerko (2020) or Ng et al. (2021b) that AI literacy is not about programming per se, but about understanding AI concepts.

4.2. Implications for research

One of the most important implications for research on AI literacy in higher and adult education is the ongoing discussion on what should and should not be a part of AI literacy, which has not yet been conclusively determined. For example, it has not yet been decided whether programming skills are a part of AI literacy, and whether there is some sort of "basic vocabulary" about AI that is cross-disciplinary and should be mastered by every person regardless of their profession or discipline. The development of an updated and more recent "AI vocabulary", somewhat comparable to the one proposed by Novak (2005), is an important and relevant task for future research in AI literacy in higher and adult education. Furthermore, there are relatively few experiments and very little fundamental research in the area of AI literacy. Although the research field is very practical, it is important to find out how different populations respond to different teaching opportunities and what teaching materials are appropriate for teaching AI content. Although field research adds a lot of value and tries to answer this question, more experiments should be conducted in the future to manipulate learning conditions in a controlled environment. Finally, yet importantly, the call for a psychometrically validated scale to measure AI literacy (Ng et al., 2021b), either as an instrument for self-assessment or as a performance test, should be emphasized once more. The existence of such a scale would not only facilitate the evaluation of the courses, but also enable comparability between different teaching formats. It can even be assumed that the creation of an AI literacy measurement instrument would advance the theory of AI literacy, since the creation of items, questionnaires, etc. often requires a structured approach to the topic, which cannot be found in every study of the currently available literature.

4.3. Implications for practice

The fast development in the field of AI literacy in general and AI literacy in higher and adult education in particular makes general statements rather difficult. However, an important "lesson learned" is that new courses should always be evaluated as thoroughly as possible in order to ensure accountability and good teaching practice (Hounsell, 2003). Teachers and faculty should draw inspiration from other courses or published curricula and be careful not to fall prey to the "Not-Invented-Here" syndrome (Grosse Kathoefer & Leker, 2010). The analysis of the courses presented in the review can be used as a starting point for AI teachers and course developers, which can then delve deeper into the relevant literature. Furthermore, there seems to be a consensus that AI skills should not only be taught in children or school age, but are also essential for students in higher and adult education. On the one hand, this is made clear by the statements of the researchers. On the other hand, the students themselves are already demanding that there should be more educational opportunities in this promising area (Wood et al., 2021).

4.4. Limitations

A major limitation in examining literature in the area of AI literacy in higher and adult education is the wide variation in terms of the quality of published studies. While some studies are methodologically sound, others bear a strong resemblance to previously published articles, have linguistic weaknesses, or contain other methodological problems. Furthermore, it was not possible to conduct a systematic review or meta-analysis because of the different theoretical and methodological bases. Another limitation is the exclusive consideration of English-language literature. While most of the articles on the topic were published in English, some articles were nevertheless found exclusively in Korean and occasionally in Chinese. Accordingly, future reviews on this topic could translate these papers in an attempt to integrate studies from the Asian education culture. In addition, we searched exclusively for studies that included the term "ai literacy" or "artificial intelligence literacy." However, the term "machine learning literacy" is also gaining relevance recently, which describes skills regarding a technique that drives most of today's AI methods. In addition to that, future research should investigate AI literacy courses or teaching programs for adults (and their assessment) in more detail. Last but not least, it should also be noted that there is no empirical evidence that AI literacy in adults (and related research) differs from AI literacy in children. Thus, the theoretical basis for the assumption described in section 1.3 should be investigated in future research, especially regarding the nature and extent of these differences.

5. Conclusion

Fostering AI literacy in higher and adult education helps to prepare (future) employees for collaboration with AI (Cetindamar et al., 2022) and might even support the creation of an ethical foundation for achieving a "Good AI Society" (Floridi et al., 2018). The current literature paints a heterogeneous picture of the AI literacy landscape and it is

difficult at this stage to make statements that present reliable information on this topic. We hope that interested researchers will continue to study this topic in detail, advance the research, and apply and test the empirical findings in teaching. A good foundation in artificial intelligence capabilities is already of great importance today, and this relevance will increase even more in the coming years. This is true not only for school students in science, technology, engineering, or mathematics (i.e., STEM subjects) or professional subject experts such as computer scientists, but for all individuals who need to find their way in a world that is, at least in part, shaped by AI. The review presented here therefore offers a first overview of endeavors in the field of AI literacy in higher and adult education and should be understood as a call for further research in this area.

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