Original Article

Presenting a comprehensive pattern of artificial intelligence in the students' education process: Meta-synthesis approach based on the Erwin Model

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Abstract

Background & Objective: Artificial Intelligence (AI) is transforming education by taking on tasks once reserved for humans, resulting in a revolution in the field. This study provides a comprehensive analysis of the components and indicators of AI in the students' education process.

Materials & Methods: This study employed a qualitative meta-synthesis approach, following the model proposed by Erwin et al. (2011). A total of 244 articles were included, consisting of scientific papers published in reputable journals such as PubMed and others, covering the years 2014 to 2023 and focusing on the role of AI in the educational process of students. A purposive sampling method was used to select 32 qualitative studies from these 244 articles. Data were collected through qualitative analysis of the documents. Scott's (2012) coding method was used to ensure the coding process's reliability, as MacHie (2012) recommended. The inter-rater reliability was calculated at 85.4%.

Results: Based on the analysis of the selected qualitative studies, the components of artificial intelligence in the students' education process were categorized into six major dimensions and 21 sub-components. The identified dimensions include: (1) Knowledge of AI Elements (e.g., educational and learning approaches, program structure, effective learning strategies, educational impact, and learning perception), (2) Planning Knowledge (e.g., curriculum design and educational planning), (3) Humanistic Knowledge (e.g., emotional literacy, motivation, creativity, and interpersonal interaction), (4) Contextual Knowledge (e.g., understanding of culture, social context, and professional skills), (5) Meta-Knowledge (e.g., perceptual insight, experience-based learning, creative cognition, and technological proficiency), and (6) Attitudinal Knowledge (e.g., learners' positive or negative attitudes toward AI in education).

Conclusion: Based on the findings, effectively applying AI in the educational process requires attention to several key elements. These include AI literacy, planning knowledge, humanistic knowledge, contextual knowledge, meta-knowledge, and attitudinal knowledge for learners across all fields.

Keywords: meta-synthesis, artificial intelligence, education process, student

Introduction

Scholars have proposed numerous definitions of intelligence in the humanities, particularly in psychology. Researchers provide a distinct definition based on their studies. In everyday discourse, "intelligence" is frequently used to expedite our understanding of human behavior. Over the years, computer and information technology advancements have led to the development of artificial intelligence (AI). In modern terms, AI refers to a machine's ability to communicate, reason, and act independently in familiar and novel scenarios, similar to humans [1].

Life in the digital knowledge age is centered on technology, with AI technologies penetrating all aspects of life, including education [2]. AI represents the pinnacle of computer technology, innovation, and information and communication technology advancements. Recently, teaching and learning methods have undergone significant and widespread

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technological advancements [3], as exemplified by the use of AI in education [4].

This has led to advancements in innovations related to digital content development using AI technology [5]. AI's primary goal is to optimize routine processes, enhancing speed and efficiency. As a result, the number of AI applications and services continues to grow worldwide [6].

Since 2020, Iran has launched a Smart School program to leverage advanced technologies such as AI, machine learning, and virtual reality to improve teaching and learning. The program includes providing technological equipment, developing intelligent educational systems, and providing technical support for schools. Preliminary results suggest that this initiative has significantly improved the quality of education, boosting student engagement and enhancing overall educational efficiency [7].

This innovative approach to teaching and learning is expanding rapidly. AI in education holds immense potential for transforming the learning and teaching process. By providing personalized learning experiences, intelligent recommendations, and immediate feedback, AI can empower educators to better understand the learning process and offer students a more effective learning experience [8].

These technologies provide new capabilities, enabling teachers and students to revolutionize the teaching and learning process more efficiently and effectively [9]. By utilizing these technologies, teaching methods are improved, and students gain a deeper understanding of concepts; consequently, the quality of education is enhanced and more knowledgeable and successful students are cultivated. For instance, AI can deliver personalized learning experiences, while virtual reality can create interactive educational environments [10].

Although this technology cannot replace the essential role of teachers in education, when used in conjunction with training for expert educators, it can enhance learner engagement, facilitate timely feedback from teachers, and tailor the learning process across various subjects [11]. Therefore, in a rapidly changing world, digital technology significantly impacts all societies. New forms of technology are constantly emerging, shaping our lives and captivating young people. As a result, schools have no choice but to make room for digital technology [12].

AI provides numerous benefits for both teachers and students. AI applications enable students to study independently at their own pace and connect with experts and educators, allowing them to access comprehensive information whenever needed. Additionally, AI can help educators create personalized student learning experiences [13]. AI, with its ability to accurately analyze each students' strengths and weaknesses, adjusts the pace of learning in a personalized manner to achieve optimal learning outcomes [14]. This innovative technology identifies and addresses existing challenges in the learning process and corrects misconceptions [15]. The use of new educational technologies plays a significant role in improving students' learning outcomes [16].

AI has revolutionized teaching methods, driving educators towards innovative pedagogical approaches [17]. By leveraging this technology, the intelligent distribution of educational tasks has been enabled, significantly enhancing the efficiency and effectiveness of the educational process in schools [4].

Although AI has provided numerous and significant educational benefits, it faces serious challenges that require careful consideration to ensure its safe and effective use in educational settings [18]. One of the primary challenges of using AI in education is safeguarding students' privacy [19]. The collection and analysis of vast amounts of student data create concerns about misusing sensitive personal information. This data could be inappropriately sold to marketing companies, used to manipulate educational outcomes, or exploited for other malicious purposes [20].

AI is a double-edged sword in scientific research. Its remarkable potential and the versatility of its applications have made it a valuable tool in numerous research institutions. However, it's irresponsible and exploitative use can transform it into a controversial tool that faces severe criticism from researchers across different fields [21]. Consequently, researchers believe that AI technologies significantly impact education and learning positively and negatively within the education industry [22]. Therefore, it is necessary to investigate the components and indicators influencing AI in the students' education process.

To ensure that AI tools contribute to human progress, educational institutions must actively develop tools, policies, and accountability mechanisms that safeguard human rights [23]. Therefore, in this research, considering that the goal of meta-synthesis is to develop theory, summarize, and generalize results findings at a high level to enhance the accessibility of qualitative findings for practical applications [24], and given that qualitative studies often aim to elucidate the why and

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how of a particular phenomenon or human experiences [25], and for this reason, in this research, we aimed to design an AI pattern by reviewing the existing research background in the field of AI. The data will be analyzed based on the following research question: What are AI's influential components and indicators in the Education process of students?

Materials & Methods

Study design

Meta-synthesis is a form of qualitative research that resembles meta-analysis. It involves examining information and findings from other studies on related and similar topics [26, 27]. As a result, the sample for meta-synthesis consists of selected qualitative studies based on their relevance and similarity to the research question. Meta-synthesis does not aim to provide a comprehensive summary of the findings; rather, it creates an interpretative synthesis of the results [28].

Meta-synthesis aims to develop theory, provide high-level summaries, and generalize findings to make qualitative research results more accessible for practical applications [24]. The research area includes all reputable scholarly articles on AI in students' education. On the other hand, a researcher-designed worksheet was utilized to collect and record data from the initial research. A categorical approach to content analysis was employed to examine the existing scientific documents and evidence within the research field. The data obtained were analyzed using a three-stage process: open, axial, and selective coding. The six-phase meta-synthesis framework proposed by Erwin et al. was used to analyze the findings [29]. Four additional coders were employed to code the data independently to ensure the reliability of the coding process. Following the methodology established by McHugh, Scott's pi coefficient was used to assess inter-rater reliability. The results indicated an inter-rater agreement of 85.54, suggesting a high level of consistency in coding among the raters [30].

$$C.R = \frac{\text{Number of agreed categories}}{\text{Total number of categories}} \times 100$$

$$C.R = \frac{54 + 59 + 57 + 49}{4 \times 64} \times 100 = 85.54$$

Steps of the Erwin Method

This section employs a six-phase meta-synthesis process based on the framework developed by Erwin et al. [29]. A summary of these stages is presented in **Figure 1**.

Step 1. Formulation of the research question

The first step in any research is to formulate a research question. The specific research questions and their corresponding parameters are detailed in **Table 1.**

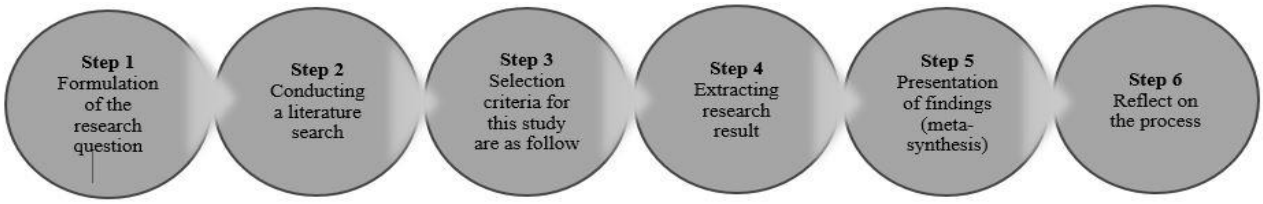

Figure 1. Steps of the six-phase meta-synthesis process based on Erwin et al.'s framework

Table 1. Research questions and corresponding parameters

Parameters	Formulating a research question
Research question	**The main question is as follows:** What are the indicators and components of artificial intelligence in students' education? **Sub-questions:** **A.** What elements affect artificial intelligence in the educational process of students? **B.** What are the indicators and components of artificial intelligence in students' education?
What (study question)	Several databases and search engines were examined in this research.
Who (study population)	Studies related to artificial intelligence in students and existing patterns in this field will be analyzed.
When (time limit)	The studies reviewed were conducted from 2010 (or 2013 in the Persian calendar) onwards.
How (information collection method)	This research employed a meta-synthesis approach. Studies were selected based on specific criteria, and those that did not meet these criteria were excluded.

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Step 2. Conducting a literature search

A systematic review was conducted to identify published and electronic research articles focusing on AI in education for students, covering the period from 1393 in the Persian calendar (2016). This timeframe was chosen for two primary reasons: first, to ensure the findings are current and relevant, and second, to support a systematic and organized research methodology and the search for scientific resources.

A comprehensive online search was conducted to compile a complete collection of relevant studies. For each identified study, a full-text copy and a complete list of references were collected electronically.

Initially, all relevant scholarly articles and credible sources were identified through keyword searches using "artificial intelligence" and "artificial intelligence in the students' education process" in databases such as SID, Normagas, Magiran, the Comprehensive Portal of Humanities Sciences, and the Persian Science Net search engine. International databases, including Google Scholar, Scopus, Emerald, Science Direct, Springer, PubMed, Wiley, Taylor and Francis, and IEEE, were also explored. A thematic analysis of the results within the specified timeframe (1393-1403 AD or 2014-2023) yielded 244 relevant studies.

Step 3. Selection, refinement, and organization of studies

At the beginning of the search process, researchers assessed whether the identified reports aligned with the research objectives. Inclusion and exclusion criteria were established to facilitate this, and the studies were evaluated based on these criteria.

A. The inclusion criteria for this study are as follows

1-Published studies in the field of AI in the students' education process.

2-Related studies from the beginning of the year 1393 in the Shamsi calendar to the year 1403 and from the beginning of 2014 to 2023 in the Gregorian calendar.

3-Research studies must have employed qualitative research methods.

4-Research studies must provide sufficient data and information to address the research objectives. Therefore, the adequacy of a study is determined by its ability to report on the indicators and components of AI in student education processes.

5-Research that has undergone a rigorous peer-review process and has been published in full, either online or in print.

B. The exclusion criteria for this study include the following

1. Studies that were in a language other than English and Persian

2. Studies that did not provide sufficient information regarding the objectives of this research, in other words, solely focused on the impact of AI on students' Education processes without considering other educational and training variables.

3. Studies of poor scientific quality were disseminated through non-reputable journals and conferences.

4. Studies published before 2014 (1393 in the Persian calendar) fall outside the timeframe of this research and contain outdated or irrelevant information for the current context. A thematic search was conducted in the designated search engines using keywords related to the research topic, specifically focusing on AI and its application in student education processes to assess the research landscape. Two hundred forty-four valid scientific documents, including research articles, were identified during this phase. Among them, 23 were removed due to duplication, leaving 221 studies. In the second stage, the studies' titles were reviewed per the established inclusion and exclusion criteria. As a result, 52 studies were excluded due to using a quantitative method, and 94 scientific studies were excluded due to their lack of quality and compliance with the established criteria. In the subsequent stage, the abstracts of the research documents were scrutinized. Based on the established criteria, 24 studies were excluded from the research process. Subsequently, a content analysis of the remaining documents was conducted, eliminating an additional 19 studies that did not meet the specified inclusion and exclusion criteria. To enhance the quality of the research, two individuals with extensive knowledge of search methodologies and information sources conducted separate literature searches. Screening and selecting studies for inclusion followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method [31]. To improve the comprehensiveness of the search, two experienced researchers independently conducted literature reviews using a variety of databases and search strategies.

Furthermore, two professors provided oversight for the study's implementation. Finally, 32 scholarly research articles published in reputable journals were selected for inclusion in the analysis. Figure 2 illustrates the continuation of the screening process for the identified studies based on the established criteria..

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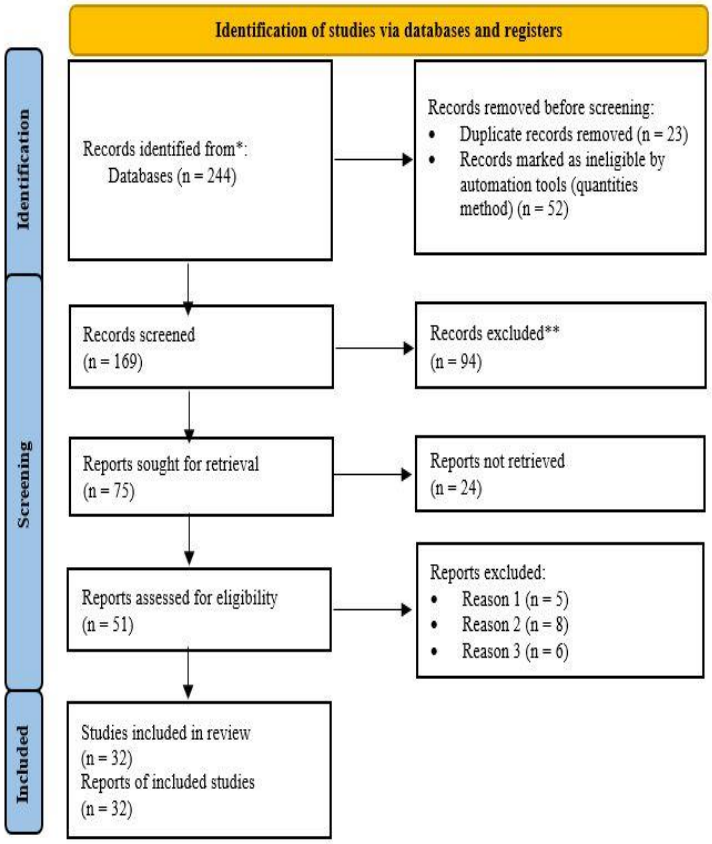

Figure 2. PRISMA flow chart for literature review study to search and select articles

Step 4. Extracting research results

Throughout the meta-synthesis, researchers systematically and repeatedly review the selected reports to identify findings from the original primary studies included in the analysis. At this stage, all relevant components related to the research objectives are extracted through open coding. Consequently, the coding results from this initial stage are summarized in **Table 2** as components of AI in the student education process.

Step 5. Presentation of findings (meta-synthesis)

At this stage, researchers must present what has emerged from the qualitative meta-synthesis process. To effectively present the findings, various audiences must be considered. According to Erwin and colleagues (2011), researchers should utilize visual elements (charts, images, and tables) to present their findings [29]. Initially, in the meta-synthesis phase, the features, elements, and components of artificial intelligence involved in the educational process of students were extracted. Meta-synthesis is a form of qualitative research that is very similar to meta-analysis and involves examining information and findings extracted from other studies on related and similar topics [26, 27]. This is why, in the beginning, all component descriptions, similar to open coding in grounded theory, were identified through key themes (first iteration). Subsequently, in the product phase, given that this section aims to integrate all scientific findings on a specific topic and achieve a unified understanding. In the results section, the qualitative analysis of key themes (first iteration) was conducted, and by re-coding, overlapping and conceptually similar codes were combined to extract core categories (key themes (second iteration)) similar to axial coding in grounded theory. To categorize all AI components and indicators in the educational process for students based on a common concept, key themes (second iteration) were conducted using the AI in education framework.

This resulted in identifying six dimensions (selected codes), including knowledge of AI, planning, humanistic knowledge, contextual knowledge, meta-knowledge, and attitudinal knowledge. These results, including key themes (second iteration) and key themes (iteration dimensions (similar to selected code in grounded theory)), are presented in **Table 3.**

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Table 2. Documents reviewed to identify factors affecting AI in students' education process

Article code	Authors' names	Year	Article title	Indicators and Components of Artificial Intelligence in Students' Education	Journal
			Internal investigations		
1	Shahmohammadi [32]	2024	The role of artificial intelligence on improving educational processes	Artificial intelligence, Education, Learning, Application of artificial intelligence in education	Strategic Research Magazine in Education and Training
2	Khademlu and Khademlu [13]	2024	Achievements of artificial intelligence in the quality of education and the teaching and learning process	AI, Quality of education, Teaching and learning process	Specialized Scientific Journal of Human Sciences in the Third Millennium
3	Jafari et al. [20]	2023	. Artificial intelligence and new technologies in educational systems, opportunities and challenges	AI, New technologies in educational, Educational justice, Personal learning experience, Simplify administrative tasks, Advanced teaching methods, Ethical issues, Investing in teacher training	Quarterly Journal of New Researches in Education
4	Yahiizadeh Waqfi and Khaki Vatan [33]	2023	Artificial intelligence technology in improving the education process: methods, opportunities and challenges	AI, Creativity, Improving the education process, Opportunities and challenges, Education, Students	Psychological Studies and Educational Sciences
5	Namdar et al. [34]	2023	The role of new technologies and artificial intelligence in improving the quality of education and teaching of teachers.	The role of new technologies, AI, Improving the quality of Education and teaching, Improving the level of thinking, Focus and attention, Progress, Increasing productivity and efficiency, Education content	Sexual and Psychological Disorders
6	Shahbazi Koohi et al. [35]	2023	Application of artificial intelligence in teaching and learning	AI, Application of artificial intelligence in teaching, Application of artificial intelligence in learning, Learning, Students, Technology	Sexual and Psychological Disorders
7	Mir Ashrafi [36]	2023	Using artificial intelligence in teaching new approaches in personalizing the learning process	AI, Education, Learner, Instructor interaction, System, Personalize learning	New Approach in Islamic Studies
8	Khayami et al. [37]	2023	Integration of artificial intelligence in education and learning	Education, Integration of artificial intelligence in Education, Integration of 9artificial intelligence in learning, Learning, Virtual reality	Studies in Psychology and Educational Sciences
9	Mohammadi et al. [38]	2023	An evaluative review of the use of artificial intelligence in public education	AI, Education, Learning, evaluative review	Educational Technologies in Learning
10	Nader [39]	2022	The use of artificial intelligence in education and learning based on a systematic literature review	AI, Education, Learning, Communication and interaction, Personalization in teaching and learning, Interactive systems based on artificial intelligence, Interaction between individuals and educational systems, Provide personalized guidance, Improving learning	Dynamic Management and Business Analysis
11	Bayat [40]	2022	The functions of artificial intelligence in the field of education and transfer of electronic knowledge	AI, Electronic education, Information Technology, Electronic data transfer and training, Technological advancement, Technology	Arman Processing Quarterly
12	Soleimanikia et al. [41]	2021	Artificial intelligence in education and learning	AI, Education, Learning, Effective technology interaction, The role of teachers, Growth, Progress, Flexible educational process, Individual needs	Paya Shahr Specialized Scientific Monthly
13	Zarari et al. [11]	2021	An overview of the applications of artificial intelligence and virtual reality in education	Artificial intelligence, virtual reality, Education, Technology, Complementary, Role of humans, Appropriate design, Motivation, emotions, Principles, Ethics, Smart program, Scientific and technological, Progress, Educational tools	Educational Measurement and Evaluation Studies

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14	Kazemi Flourdi [42]	2020	The use of artificial intelligence in education and learning	Training, Learning, Saving money and Time, Collaborative learning	Rushd Magazine
15	Mehrparsa [43]	2020	Artificial intelligence and its application in education	Providing adaptive education, Accurate feedback from students, Improving the educational process, Effective learning experience	Management and Entrepreneurship Studies
16	Fahimirad and Kotmjani [44]	2018	An overview of the application of artificial intelligence in teaching and learning in educational fields	Creativity, Imagination, Innovation, Skill-based, new learning, Learning opportunity, Technological advancement	International Journal of Learning and Development
			External investigations		
17	Kassymova et al. [45]	2021	Ethical problems of digitalization and artificial intelligence in education: a global perspective	Digital culture, learning technology, social transformation system, social system and culture formation, digital addiction, dehumanization, narcissism, distrust.	Pharmaceutical Negative Results
18	Su, Ng and Chu [46]	2021	Artificial intelligence (AI) literacy in early childhood: the challenges and opportunities	AI curriculum, Age-appropriate tools, AI literacy	Computer and Education Artificial Intelligence
19	Cian, et al. [47]	2020	Artificial intelligence and conversational agent evolution-a cautionary tale of benefits and pitfalls of advanced technology in education	AI, Advantages and Disadvantages of Advanced Technology in Education,	Journal of Information, Communication and Ethics in Society
20	Kizlicec [48]	2020	To advance AI use in education, focused on understanding educators	Progress of cognitive science, Profound social impact, Rational and cultural factors, Academic achievements, Technology acceptance, Trust	International journal of artificial intelligence in education, Advance online publication
21	Kamalov et al. [49]	2018	New era of artificial intelligence in education: toward a sustainable multifaceted revolution	Deep learning, Confidence and sustainable development, Collaborative learning, Quality education, AI literacy, Education ethics, Part of the curriculum, Negative aspects, Ethical issues, Automated grading system	Journal of Sustainability
22	Limna et al. [50]	2018	A review of artificial intelligence (AI) in education during the digital era	Strategic and vital factor in the development of education, Digital assistant, Student access to educational materials, More effective learning activity, Distance learning education and improvement, Privacy, Adaptive learning.	Advance Knowledge for Executives
23	Krstić, et al. [51]	2017	Artificial intelligence in education: a review	Adaptive learning, Student learning, Teaching method, Personalization process	Technics and Informatics in Education
24	Tambuskar [14]	2021	Challenge and benefits of 7 ways artificial intelligence in education sector	Education and learning in the digital age, Element of academic progress, Personalization, Enhance learning experiences, Privacy issues, Artificial intelligence (AI) development, Challenges and benefits	Review of Artificial Intelligence in Education
25	Tapalova and Zhiyenbayeva [52]	2021	Artificial intelligence in education: AIEd for personalized learning pathways	Personalized events, Intelligent agents, Personalized learning paths, Personal needs of students, Increase student engagement, Psychological aspects, Academic progress, Social and economic life	Electronic Journal of E-learning
26	Seo, et al. [53]	2020	The impact of artificial intelligence on learner-instructor interaction in online learning	AI, Education, Learning, Opportunities and Challenges, Impact on Communications, Quality and Quantity, Responsibility, Timely Support for Learners, Autonomy, Improvement of Communications, Privacy, Development of Human Participation, Education and Awareness, Creativity, Increasing learners reflection	International Journal of Educational Technology in Higher Education

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27	Savas [54]	2020	Artificial intelligence and innovative application in education: the case of Turkey	Daily life, Digital competence of teacher, Application program, Learning habits, Idea generation, Critical thinking, Brainstorming, Digital competence problem	Information Systems and Management Research
28	Chen, Chen and Lin [4]	2018	Artificial intelligence in education: a review	Personalized curriculum, Curriculum, Improve the quality of education, Enhance the experience, Teacher effectiveness, Learning experiences,	IEEE Access
29	Grage and Sharma [55]	2018	Impact of artificial intelligence in special need education to promote inclusive pedagogy	Promoting education with special approaches, Individual life, Making students' lives easier, Safe environment for children,	International Journal of Information and Education Technology
30	Ikka [56]	2017	The impact of artificial intelligence on learning, teaching, and education	The impact of artificial intelligence on learning, teaching, and education, Future-oriented activity, AI developers, Economic and social impacts	European Union
31	Cassighol et al. [57]	2021	Artificial Intelligence trends in education: a narrative overview	Decoding students' difficulties, Social interaction, Against social interaction, Diagnosing teaching and learning gaps, Learning progress, Quality of the educational process, Content development, Teaching methods, Learning technology development	Procedia Computer Science
32	Li, et al. [58]	2021	Virtual reality and artificial intelligence support future training development	Creative learning process, Economic educational process, Artificial intelligence (AI), Educational development, The future	Paper presented at the 2017 Chinese Automation Congress (CAC)

Table 3. Dimensions of the Artificial intelligence pattern in the students' education process

Overarching theme: final iteration	Key themes: Iteration dimensions	Key themes: second iteration	Key themes: first iteration	Preliminary themes from qualitative studies (Article code)
The artificial intelligence in the education process for students	**Knowledge of AI elements**	Knowledge of educational approaches	Improving teaching methods	[4], [15], [16], [30], [31]
			Advanced education methods	[3], [9], [12], [16], [19], [25], [29]
			Application of artificial intelligence in education	[1], [6], [15]
			Education development	[16], [19], [21], [22], [29], [30]
			Adaptive education	[22]
			Effective education methods	[3], [11], [22], [23], [28]
			Advanced education method	[3]
			Creative education	[26], [32]
		Knowledge of learning approaches	Quality of education	[1], [2], [5], [6], [11], [21], [26], [28], [31]
			Effective learning	[1], [2], [5], [6], [11], [21], [28], [31]
			Teaching-learning	[2]
			Creative learning	[11]
			Collaborative learning	[4], [21], [25], [26], [27]
			Adaptive learning	[22], [23]
		Knowledge of program space and location	Educational environment	[6], [22]
			Safe educational environment	[29]
		knowledge of effective learning	Learning efficiency and productivity	[5], [6]
			Effective learning	[1], [6], [8]
		knowledge Educational impact on learner	Increase attractiveness	[8], [11]
			Focus and Attention	[5]
			Scientific advancement	[5], [6], [13], [24], [25], [33]
			Elevation of thought processes	[5]
		knowledge of learning perception	Personal learning experiences	[3], [28]
			Improving learning methods	[5], [8], [10]
			Pace and depth of learning	[31]
			Personalized education	[3], [4], [10]
			personalized learning path	[7], [10], [23], [25]

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		Personalized services	[3], [5], [6], [7], [11], [16], [23], [24], [25], [28]
		Personalized experience	[5]
	Knowledge of planning	Planning	[8], [11], [27]
Knowledge of planning	knowledge of curriculum	Proper planning and design	[11], [13]
		AI curriculum	[11], [18], [21], [27], [28]
		Proper curriculum and design	[11], [19]
		Emotions	[13]
	Emotional literacy	Flexibe	[12]
		Ethics	[3], [21]
	Knowledge of motivation	Motivation	[1], [13]
Humanistic knowledge	Knowledge of creativity	Creativity	[4], [16]
		Instructor interaction	[7], [10]
	Knowledge of interaction	Individual interaction with social media	[10], [12]
		Students interaction	[4], [10], [12]
		Culture and attitude of society	[1], [17]
	Knowledge of culture	Digital culture	[17]
		Rational and cultural factors	[20]
		Social system	[18]
Contextual knowledge	Social knowledge	Social interaction	[12], [26], [31]
		Significant societal influence	[20]
		AI information literacy	[18], [21], [24]
	Knowledge of professional skill	AI Knowledge	[18], [21]
		Skill in using AI	[16]
		Automation	[9]
	Perceptual knowledge	Self-regulation	[17], [20], [26]
		Self-control	[1]
Meta-knowledge	Knowledge experience-based	Professional experience	[28]
		Learning experiences	[15], [24]
	Knowledge creative	Creative thinking	[18]
	Technological knowledge	Technological knowledge	[20]
		Knowledge of advancements Technology	[11], [26]
		Time management	[1], [14], [19]
	Positive outlook	Economic management	[14], [19], [25], [30], [32]
Attitudinal knowledge		Infinite in time and space	[6], [19]
		Maintaining ethical issues	[3], [7], [12], [19], [21]
	Negative outlook	Privacy protection	[4], [19], [20], [22], [24], [26]
		Addiction dIgital	[17], [19]

Step 6. Presentation of findings

The researcher must be prepared to change previous stages throughout the meta-synthesis process. It is also important for each stage's reflections to be evident in the previous stages of the meta-synthesis. In this research, ethical considerations regarding honesty and integrity have been strictly adhered to in the analysis and description of the findings and in preserving the authenticity of the texts. This includes ensuring accurate representation of the original research studies and avoiding any misinterpretations or misrepresentations of the data.

Results

The meta-synthesis method is valuable for leveraging existing qualitative research to develop new theories. Conceptual models and theoretical frameworks can serve as valuable tools for enhancing students' understanding of artificial intelligence in the educational process. By meta-synthesis of previous theoretical and research findings (performing the stages of coding and axial coding), the final classification and ranking are extracted as a pattern, as shown in **Figure 3**. This AI framework for student education can be categorized and integrated into six broad dimensions: knowledge of AI element (Encompassing knowledge of educational approaches, knowledge of learning approaches, knowledge of program space and location, knowledge of effective learning, knowledge of learning perception), knowledge of planning (Encompassing knowledge of planning, knowledge of curriculum), humanistic knowledge (Encompassing emotional literacy, knowledge of

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motivation, knowledge of creativity, knowledge of interaction), contextual knowledge (Encompassing knowledge of culture, social knowledge, knowledge of professional skill), meta-knowledge (Encompassing perceptual knowledge, knowledge experience based, knowledge creative, technological knowledge) and attitudinal knowledge (Encompassing positive outlook, negative outlook). Consequently, to effectively integrate AI into the student education process, it is essential to consider each dimension and pay attention to its specific features. **Figure 3** illustrates the AI pattern in the students' education process, demonstrating that all factors are interconnected. These dimensions mutually influence each other in a non-linear relationship.

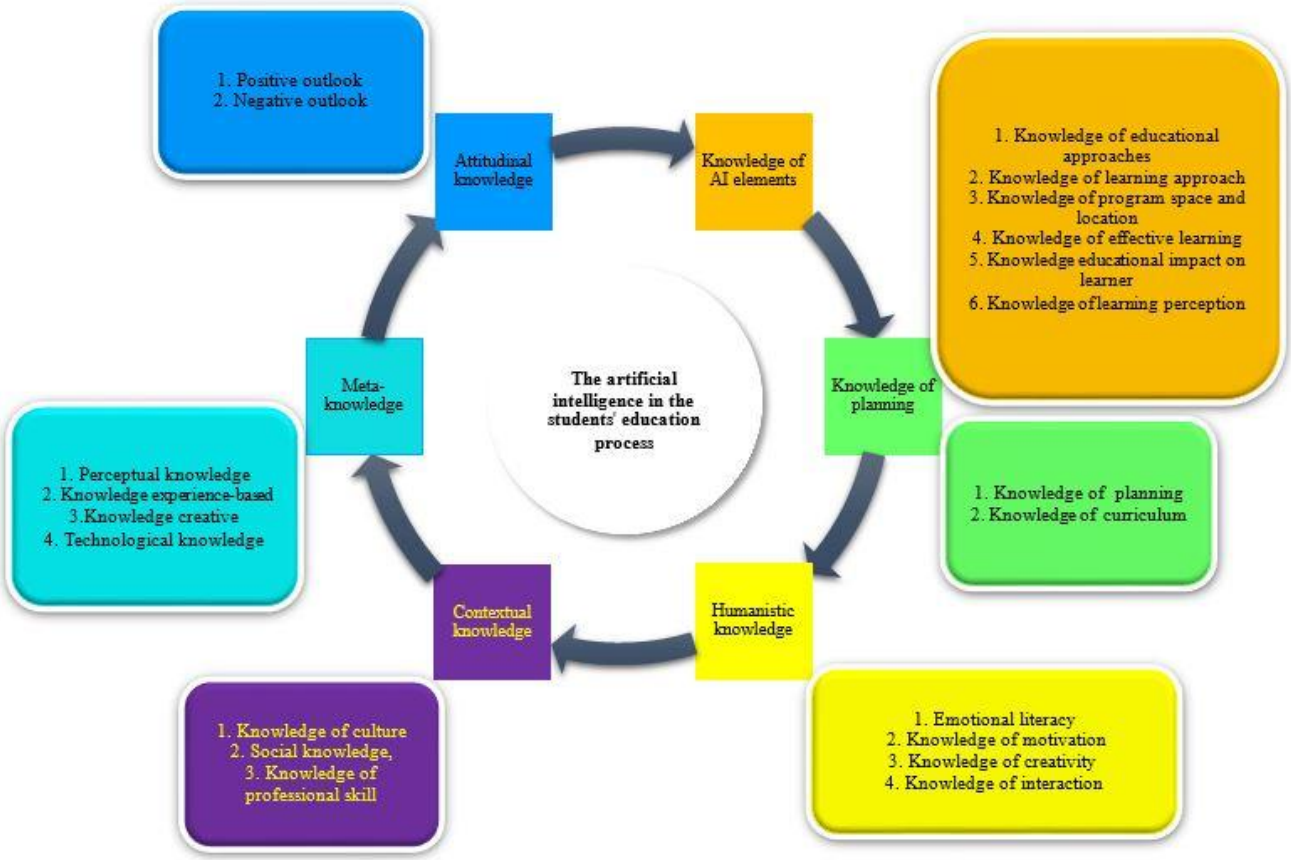

Figure 3. Dimensions of the AI pattern in the students' education proce.

Discussion

AI has become a pressing topic of discussion, especially as technology largely shapes nearly every aspect of 21st-century global life [59].

The overarching structure of educational AI research highlights the complementary roles of humans and machines in teaching [11]. AI has profoundly affected human life, and today's generation is more technologically advanced than ever. This has led to significant transformations in the realm of digital education. AI can significantly enhance the efficiency of many organizations and reduce costs [60]. AI is becoming a powerful tool for enhancing the quality of life for many individuals and ensuring lifelong learning [61].

Therefore, AI is becoming one of the most popular approaches to achieving educational goals [62]. The present study aimed to present a comprehensive model of the factors affecting research anxiety through a meta-synthesis approach.

This research is one of the studies performed comprehensively to identify and discuss the factors affecting AI in the students' education process through the meta-synthesis of prior qualitative studies. We presented new findings regarding the factors influencing AI in the student education process, which significantly impact education. The present factors affecting AI in the students' education process can be six

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categories: knowledge of AI elements, knowledge of planning, humanistic knowledge, contextual knowledge, meta-knowledge, and attitudinal knowledge.

Knowledge of AI elements

Understanding AI in the education process, interacting effectively with technology, and developing the skills needed to create personalized education will ensure teachers' role in better growth [41]. AI also contributes to improving the quality of education [59].

A review of the existing literature in this field has led to identifying areas such as knowledge of educational approaches, knowledge of learning approach, knowledge of program space and location, knowledge of effective learning, knowledge of educational impact on learner, and knowledge of learning perception. In this dimension, elements related to education and learning have been considered.

Therefore, developing knowledge regarding AI elements among education stakeholders is paramount. By increasing awareness and understanding of this field among teachers, the full potential of AI can be leveraged to enhance the educational and learning process. The findings of this part of the study are in the direction of the research of Khadem Lu and Khadem Lu. [13], Tapalova and Zhiyenbayeva. [52], Mir-Ashrafi [36], and Shahbazi-Koohi et al. [35].

Knowledge of planning

AI facilitates content personalization to cater to individual learning needs, thereby significantly tailoring educational materials [63]. A crucial aspect of using AI to enhance learning is the personalization of curricula and content to match learners' individual needs, abilities, and learning paces [64], thereby preventing the waste of learners' time and energy.

AI systems can be programmed to deliver expertise [38], and given the technology's potential for both positive and negative impacts on education, prioritizing AI in education and implementing appropriate strategies to meet the needs and expectations of teachers and learners through AI technologies is crucial.

Consequently, academic performance will be significantly enhanced [38]. Additionally, AI can automate tasks such as grading and lesson planning, freeing up teachers to focus on individualized instruction.

This study considers the importance of pedagogical planning and curriculum knowledge in this context. The findings of this part of the study are in the direction of the research of Soleimanikia et al. [41].

Humanistic knowledge

In education, the topic of relationships is very important. We should not overlook the importance of the relationship between teachers and students. Instead, we should strive to balance educational technology with the conditions needed to foster strong relationships [65]. All components and indicators identified fall under emotional literacy, motivational knowledge, creative knowledge, and interaction knowledge. This study highlights the crucial role of teacher-student relationships in effective education. While technology offers valuable tools, it's essential to prioritize the human connection. It emphasizes the significance of emotional literacy, motivational knowledge, creative capacity, and interaction skills in building these vital relationships. These elements are key to fostering a supportive and engaging learning environment. The findings of this study are in the direction of the research by Zafari et al. [11].

Contextual knowledge

Whenever a new cultural era emerges, the juxtaposition of two cultures or the introduction a new element from another culture, if embraced by the majority, can lead to significant cultural shifts. These changes inevitably influence society, cultural norms, individuals, and lifestyles [66]. Among the factors influencing AI in the educational process of students are cultural knowledge, social knowledge, and professional skill knowledge that occur in contexts that affect the level of AI. Among the factors influencing AI in the educational process for students are cultural knowledge, social knowledge, and professional skills, all of which affect the level of AI implementation. The findings of this study are in the direction of the research of Jafari et al. [20] and Kassymova et al. [45]. By recognizing and addressing the interplay of cultural, social, and professional knowledge, educators can harness the power of AI to create more personalized and impactful learning experiences for all students. This holistic approach to AI in education is crucial for ensuring that AI can augment, rather than supplant, the human element in learning.

Meta-knowledge

AI represents the pinnacle of computer-related technologies. It enables machines to autonomously acquire knowledge and information to create intelligent applications, facilitating a synergy between human and computer capabilities [67- 69]. Educational environments that integrate this technology with instruction are better aligned with society's current

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demands and challenges [70]. By integrating the findings from various studies on AI in the student educational process, we reached the dimensions of perceptual knowledge experience-based, knowledge creative, and technological knowledge. By synthesizing findings from diverse research studies on AI within students' educational processes, we have identified several key components, including perceptual, experiential, creative, and technological knowledge. The findings of this part of the study are in the direction of the research of Mohammadi et al. [38], Kassymova et al. [45], and Kizlicec. [48].

Attitudinal knowledge

Researchers believe that AI technologies affect education and learning positively and negatively within the education industry [22]. One of the primary advantages of AI is that it automates complex and time-consuming tasks, thereby freeing up time for other pursuits [71]. Another drawback of AI is its potential to compromise the importance of data privacy for teachers and students. Consequently, the lack of ethical frameworks in educational contexts and the widespread use of AI can lead to ethical dilemmas [72]. Our analysis reveals two overarching dimensions of AI's impact: a positive outlook and a negative outlook. While AI has the potential to revolutionize education by automating tasks, personalizing learning and providing data-driven insights, it can also enhance accessibility and engagement for students. However, it is important to be aware of the potential risks of AI in education. By carefully considering the ethical implications of AI and implementing appropriate safeguards, we can ensure that AI is used in a way that benefits all students. The findings of this part of the study are in the direction of the research of Kazemi Flourdi. [42], Cian et al. [47].

Conclusion

As an emerging technology, AI has revolutionized various aspects of life, including education. By providing innovative tools and methods, AI can significantly enhance the quality and effectiveness of student education, holding transformative potential for the entire field. Given these numerous benefits, investing in the development and application of AI in education can improve educational quality and better prepare students for the future. To maximize the benefits of AI in education for students, it is essential to focus on several key areas of knowledge. These components include knowledge of AI elements (which encompasses knowledge of educational approaches, learning approaches, programming environments, effective learning strategies, the educational impact on learners, and understanding learning perceptions); knowledge of planning (which includes curriculum and planning knowledge); humanistic knowledge (encompassing emotional literacy, motivational knowledge, creativity, and interaction skills); contextual knowledge (which covers cultural knowledge, social knowledge, and professional skills); meta-knowledge (including perceptual knowledge, experiential knowledge, creative knowledge, and technological knowledge); and attitudinal knowledge (comprising both positive and negative outlooks).

Educational systems are actively seeking ways to improve the integration of AI in student education. This aligns with global trends in AI education, which are seeing a surge in personalized learning platforms, intelligent tutoring systems, and AI-powered assessment tools. These trends reflect a growing recognition of AI's potential to address diverse learning needs and improve educational outcomes on a large scale.

However, the integration of AI in education is not without its challenges. Researchers and educators are grappling with ethical considerations surrounding data privacy, algorithmic bias, and the potential displacement of human interaction in the learning process. This research contributes to the global conversation by identifying key components and indicators of AI in student education.

This research has taken an important first step in identifying the core components of AI integration in student education in Iran. However, further investigation is needed to fully understand these components' complex interplay and impact on students learning. Future research could explore the following avenues:

Comparative studies

Comparing the identified components with those found in other educational systems, both nationally and internationally, could reveal best practices and areas for improvement. This would contribute valuable data to the global discussion on AI in education.

Impact assessment

Longitudinal studies assessing the impact of AI-driven educational interventions on students' learning outcomes, including academic achievement and socio-emotional development, are crucial.

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Teacher training

Investigating the training and professional development needs of educators in the age of AI is essential. Teachers need to be equipped to integrate AI tools effectively into their classrooms and address any ethical considerations that may arise.

Students' perspectives

Gathering students' feedback on their experiences with AI-driven educational tools and platforms is crucial for ensuring that these technologies meet their needs and promote effective learning.

By addressing these research gaps, we can move toward a more informed and responsible implementation of AI in education, maximizing its benefits while mitigating potential risks.

This will not only improve the quality of education within Iran but also contribute valuable insights to the global effort to harness AI's power to improve education.

Educational systems are exploring ways to enhance the use of AI in the educational process for students.

Given the growing importance of AI, it is crucial to take steps toward integrating AI into students' learning processes, no matter how small.

The initial step toward institutionalizing AI in students' education is to identify the key components and indicators of AI in the education process for students.

Therefore, in this research, we endeavored to identify the indicators and components of AI in students' education processes.

Hopefully, we have taken a small step toward strengthening and developing AI in the educational process for students in our beloved country.

Ethical considerations

Further research should focus on developing ethical frameworks specifically tailored to the use of AI in education. This includes addressing data privacy issues, algorithmic transparency, and ensuring equitable access to AI-powered educational resources.

Artificial intelligence utilization for article writing

Artificial intelligence (AI) has not been used for writing this article.

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Conflict of interest statement

We declare that there are no conflicts of interest related to this paper.

Author contributions

AM was involved in presentation, idea development, compilation and writing, analysis and conclusion, technical research editing, sub-editing, magazine editing, and article revising. HMM and AAA supervised the study.

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The data are available from the corresponding author.

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