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Reflections of artificial intelligence on science education in Türkiye

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Abstract

Aim: The aim of this study is to analyse the studies of theses and research articles published in Türkiye related to the use of artificial intelligence in science education between 2010-2023 through the databases of "Google Scholar", DergiPark and "National Thesis Center of the Council of Higher Education" by descriptive content analysis method and to examine them in terms of various variables.

Method: A total of 35 publications, of which 17 were theses and 18 were articles, were considered appropriate for the study in question for descriptive content analysis. In this study, the publications retrieved from the relevant databases were examined in terms of their distribution according to keywords, types of research, sampling methods and sizes, data analysis methods, diversity of study groups, publication years, research methods and designs, and data collection instruments within the framework of the specified research questions.

Results: The results of the study indicated that 145 keywords were identified. The analysis revealed that the majority of the studies on artificial intelligence were research articles. However, it was observed that content analysis was the predominant data analysis method employed.

Suggestions: It is suggested that, in addition to the study of 'artificial intelligence' and its application areas, which are the focus of increasing academic research, further studies should be conducted on science education subjects.

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1. INTRODUCTION

Technological development has been rapid in recent centuries, with new inventions and innovations being made at an increasingly frequent rate. Examples of such developments include the printing press, the computer, the internet, and artificial intelligence. These developments have become increasingly prominent in the present century and have begun to be utilised in a variety of fields. From industry to the military, from health to agriculture, education has of course had its share of these developments in many areas that we can think of and continues to do so. In education, which has had its share in the development of technology, the most basic of the new concepts we encounter is undoubtedly the concept of 'educational technology'. Şimşek et al. (2008), while defining this concept, stated that it has moved away from the definition of 'tools and equipment used in education' over time and has become a discipline in itself, developing in the process and covering many subjects. Educational technology is constantly renewing and expanding its scope with the rapid development of technology. Thus, the technological studies used in the field of education are increasing day by day (Zengin et al., 2024).

The increase in industrialisation with the Industrial Revolution and the parallel development of technological studies have increased human adaptation to this development process. As a result of the innovations and changes that started with Industry 1.0 and gradually reached the present with Industry 2.0, 3.0 and finally 4.0, artificial intelligence and cloud storage technologies have started to be used in Industry 4.0. All these can be considered as steps towards the transition from the information society to the super smart society (Saracel & Aksoy, 2020). Artificial Intelligence, which has become popular in the world and in our country in recent years, has increasingly important applications in everyday life and is one of the important fields of study for many disciplines. As AI has started to take place in our education system today, students at various levels of education are taking courses on learning AI.

1.2. Artificial Intelligence Techniques and Application Areas

In 1950, artificial intelligence appeared on the agenda with Alan Turing's machine called 'Information Processing Machines and Intelligence' and was first used as a name at the Dartmount Meeting in 1956. However, it is known that the history of artificial intelligence goes back to a more distant past (Pirim, 2006). The works of the Muslim scholar Al-Khwarizmi (780-850) in the field of algorithms and mathematics form the basis of AI modelling, especially in the field of finance (Yurdagel & Karaca, 2023; p.17). On the other hand, it can be said that the works of another Muslim scholar Al-Jazari (1153-1233) in the field of engineering related to artificial intelligence also played an important role in forming the foundations of artificial intelligence (Yaşın, 2006).

The first machines that formed the basis of artificial intelligence were created in the 17th century by Wilhelm Schickard (1623), Blaise Pascal (1642) and G. W. Leibniz (1671). What these machines have in common is that they were the first mechanical and digital calculating machines of their time. Thus, it can be said that the study of artificial intelligence began with the first mechanical and digital machines (Erümit et al., 2020). In the 18th century, with the beginning of the industrial revolution, automatic machines were invented, and many other inventions paved the way for artificial intelligence (Kapır, 2022). In the 19th century, a step forward was taken, and the first programmable machines were designed (Erümit et al., 2020). The most important developments in the field of artificial intelligence took place in the 20th century. First, in 1943, Warren McCulloch and Walter Pitts introduced the first artificial neural network model based on the computation and analysis of the human brain (Keskenler & Keskenler, 2017). Then, in 1948, Shannon suggested that computers could prove complex mathematical theorems and play chess. In 1950, the British mathematician Alan Turing proposed the idea of the 'Turing test' in his article, in which he attempted to answer the question "Can machines think?" (Arslan, 2020). In response to this test, John SEARLE of the University of California proposed the 'Chinese room experiment' (Pirim, 2006).

Following the advent of artificial intelligence, a plethora of definitions have been proposed (Nabiyev, 2021). The inaugural explanations and definitions of artificial intelligence were provided by McCarthy in 1956. McCarthy's seminal work defined artificial intelligence as the science and engineering of constructing human-like intelligent machines and computer programs (Arslan, 2020). However, many areas of application have developed thanks to the development of artificial intelligence. Important areas include the defence industry,

education, medicine, law and engineering (Karaduman, 2019; Nabiyev & Erümit, 2022).Along with these areas, many sub-branches for artificial intelligence have started to emerge. Some examples of these are artificial neural networks, deep learning, machine learning, fuzzy logic, educational data mining, genetic algorithms and expert systems (Elmas, 2021; İnal, 2021).

With the development of artificial intelligence, many techniques related to artificial intelligence have emerged and application areas have developed (Bozüyük et al., 2005). In many studies in the literature, application areas related to artificial intelligence are classified as data mining, machine learning, natural language processing, speech, expert systems, planning, scheduling and optimisation, robotics and vision (Adalı, 2012; Atlam et al., 2018; Akgöbek & Çakır, 2009; Atalay & Çelik, 2017; Doğan & Türkoğlu, 2018). On the other hand, in the study of Deperlioğlu and Köse (2023), the application areas of artificial intelligence are described under three main headings as cognitive science, robotics and natural interface applications. The 'Artificial Intelligence Applications Course Program for secondary school students was published by MoNE (2023a). The programme incorporates a range of concepts related to artificial intelligence, including 'machine learning and pattern recognition', 'artificial neural networks', 'fuzzy logic', 'developing sample projects in a block-based environment', 'data mining' and 'image processing'.

1.2. Artificial Intelligence Applications, Courses and Science Education

A significant corpus of research in the domain of artificial intelligence, a major innovation in technology, has demonstrated the impact of artificial intelligence on education (Akdeniz & Özdinç, 2021; Bahroun, 2023; Feng & Law, 2021; Ferreira de Menezes et al., 2023; Guan & Jiang, 2020). The importance of artificial intelligence in enhancing the quality of education is well-documented (Nabiyev & Erümit, 2022), and the integration of smart technologies in education has been shown to be beneficial (Ferreira de Menezes et al., 2023). The utilisation of artificial intelligence technologies in education has been demonstrated to facilitate learning and enhance learning environments (Alan & Zengin, 2023).

A considerable number of applications based on artificial intelligence have been developed for use in learning and education. Examples of artificial intelligence systems in education include personalised education systems, curricula, assessment tools based on artificial intelligence and exam management systems (Arslan, 2020). In the study conducted by Gürlek et al. (2023), the effects of artificial intelligence on education were explained under the following titles: personalising education according to the needs of students, automating students' basic educational activities, ensuring students' development, changing the structure of education and the roles of teachers, providing feedback to students and completing students' deficiencies. On the other hand, the integration of smart education technologies into education is important for the use of artificial intelligence technologies in education. Machine learning, data mining and learning analytics are technologies closely related to education (Chen et al., 2020).

It is evident that a multitude of applications can be developed utilising Python as a programming language in the context of artificial intelligence in education. The majority of artificial intelligence software and applications encountered in education are found and used in online environments. Examples of such applications include Gradescope, which facilitates the distribution of homework to students, Hubert, which conducts written interviews with students and provides feedback, SuperSaas, which plans activities for students, and various Google applications (Akgündüz, 2019). In addition, 'Evernote', which translates sound into writing, 'Turnitin', another online application that compares similarities in different documents and reveals similarity rates, and similar applications, are artificial intelligence applications (Nabiyev & Erümit, 2022). Within the national context, the 'EBA Assistant' (2020) is an artificial intelligence-based application offered to students by the Ministry of National Education, designed to respond to queries posed by users of the EBA platform.

In addition to the aforementioned points, the National Artificial Intelligence Strategy (2021-2025) was developed by the Ministry of Industry and Technology and the Presidency of the Presidency Digital Transformation Office. Activities related to artificial intelligence are planned to be realised (UYZS, 2021). The Ministry of National Education (MoNE) has been conducting studies on artificial intelligence education in recent years. As part of this programme, a curriculum and course content has been developed for the instruction of artificial intelligence. In 2023, the Ministry of National Education established an 'Artificial

Intelligence Applications Course Program' for 7th and 8th grades of Secondary School and Imam Hatip Secondary School. The subjects and concepts covered by this curriculum are as follows: 'The concept of artificial intelligence, historical development of artificial intelligence, usage areas of artificial intelligence, sub-dimensions of artificial intelligence, basic concepts of ethics in artificial intelligence applications, ethics in artificial intelligence, privacy and security, the importance of artificial intelligence, the future of artificial intelligence block-based development environments, image processing projects in block-based environments, machine learning, pattern recognition, artificial neural networks, fuzzy logic, writing-to-sound projects, sound-to-writing projects, language perception projects, language translation projects, image and sound processing and security projects. The Artificial Intelligence Applications Course Curriculum also aims to develop scientific process skills, life skills and engineering skills in students (MoNE, 2023a).

The 'Artificial Intelligence Applications Atelier Programme', as proposed by MoNE (2023b) in Türkiye, is a pioneering initiative designed to be implemented in Science and Art Centres (BİLSEM), catering to gifted students. The programme encompasses a range of subjects, including 'fundamentals of artificial intelligence, machine learning, artificial neural networks, natural language processing, fuzzy logic, artificial intelligence and ethics, artificial intelligence and ethics, project development and problem solving'. Within the context of Türkiye, an additional course on artificial intelligence is the artificial intelligence atelier, which was established by BILSEM as part of the BILSEM summer school programme. This initiative is designed to provide benefits to all students, irrespective of their enrolment status with BILSEM, who are engaged in formal education (MoNE, 2023c).

Science education is a pervasive element of the education system, spanning from preschool to higher education levels (Ouyang et al., 2022; Zhai et al., 2021). A considerable proportion of students encounter challenges in science lessons, harbour prejudices against the subject, and exhibit a diminished level of interest in the course. In such cases, the development of various applications is expected to reverse the prejudices and negative feelings that students develop against science lessons (Alan & Zengin, 2023). Çam et al. (2021) posit in their study that the utilisation of virtualised, artificial intelligence-supported applications for experimentation in science lessons will engender convenience in said lessons. It can be posited that the employment of artificial intelligence technologies in science education engenders positive results. Conversely, it has been posited that the integration of various computer and internet networks under the rubric of 'Digital competence' within the 2018 'Science programme for secondary school' is imperative, with this competence being supported by fundamental skills (MoNE, 2018).

Examples of artificial intelligence applications that have the potential to be utilised within the context of science education include the video-sharing platform YouTube, which offers a variety of educational videos and lectures; the DeepDreamGenerator, which generates alternative versions of existing images; and Experiments with Google, an artificial intelligence library. It also contains artificial intelligence applications, such as 'Quick Draw', which is a drawing development tool, 'PoseNet', which teaches and detects motion, and 'Teachable Machine', which teaches artificial neural networks to students (Akgündüz, 2019).

1.3. Rationale

After reviewing the relevant literature, we found five studies on content analysis, as well as various studies on artificial intelligence in education in our country (Akdeniz & Özdinç, 2021; Güzey et al., 2023; Meço & Coştu, 2022; Tekin, 2023). Kavut (2022) is in the general category and is a study that also deals with education.In addition, it was determined that the content analysis studies conducted in Türkiye on artificial intelligence and education were conducted using the term 'artificial intelligence in education' (Güzey et al., 2023; Meço & Coştü, 2022). However, since artificial intelligence includes many techniques, there are studies related to artificial intelligence using different keywords, and this must be considered in the content analysis to be conducted. In this study, in light of this situation, the current study was conducted in the field of science education. In terms of the theoretical framework, this study is important in terms of revealing the reflections of the developments in the field of artificial intelligence in Türkiye on science education.

1.4. Purpose of the Study and Research Questions

The aim of this study is to analyse descriptively and content-wise the theses and research articles published in

Turkey related to artificial intelligence in terms of science education and to examine them in terms of various variables.

Research questions for the current study:
1. How is the distribution of the keywords used in the studies on AI in science education?
2. How is the distribution of the studies on AI in science education in terms of articles and theses?
3. How is the distribution of the studies on AI in science education in terms of research/publication years?
4. How is the distribution of the studies on AI in science education in terms of sampling method and size?
5. How is the distribution of studies on AI in science education in terms of study group diversity?
6. How is the distribution of the studies on AI in science education according to the journals and universities in which they were published?
7. How is the distribution of studies on AI in science education in terms of research method and design?
8. How is the distribution of studies on AI in science education in terms of data collection tools?
9. How is the distribution of studies on AI in science education in terms of data analysis methods?
10. What is the distribution of AI methods, techniques and applications used in artificial intelligence studies in science education?

2. METHODOLOGY

2.1. Research Model

The present study set out to analyse the descriptive content of theses and research articles published in Turkey on the subject of artificial intelligence in terms of science education, examining them in terms of various variables. To this end, the study was conducted using the descriptive content analysis method, a qualitative research method. In descriptive content analysis studies, researchers first determine the topic, then scan the literature within the scope of the topic they have determined and thus obtain a study pool. Subsequently, they conducted a more detailed examination of the studies using keywords in relevant databases (Ültay et al., 2021). Çalık and Sözbilir (2014) categorised the content analysis method into three distinct categories: meta-synthesis, meta-analysis and descriptive content analysis. In this study, the descriptive content analysis method was selected, and the articles and theses on science education and artificial intelligence in Türkiye were identified. The data were classified, grouped systematically, transformed into tables and graphs, their trends were examined, and they were clearly described and interpreted.

2.2. Data Collection Process

In this research, the following keywords were examined: 'artificial intelligence', 'artificial intelligence techniques and applications', 'machine learning', 'natural language processing', 'speech', 'robotics', 'pattern recognition', 'artificial neural networks'. In addition to these, the keywords 'science education', 'science education', 'science education', 'physics', 'chemistry', 'biology ", 'fuzzy logic', 'data mining', 'educational interface', 'image processing', 'expert systems', 'Google Scholar', DergiPark and 'National Thesis Centre of the Presidency of the Council of Higher Education' databases were used to identify relevant studies. The search was limited to studies conducted in Turkey between 2010 and 2023. The most recent date of publication was 01.01.2024. During the review process, it was ensured that the keywords employed in the scanning study were present in the titles or abstracts of the studies. In determining the keywords, the keywords in the studies in the literature and the titles in the Artificial Intelligence Applications Course Curriculum (I-II) (MoNE, 2023a) proposed by the Ministry of National Education were found to be effective.

In the present study, a set of criteria were applied during the scanning process, and articles and theses/dissertations were identified through keyword searches in this direction. The criteria that were determined for the screening study for descriptive content analysis related to artificial intelligence in science education are as follows:

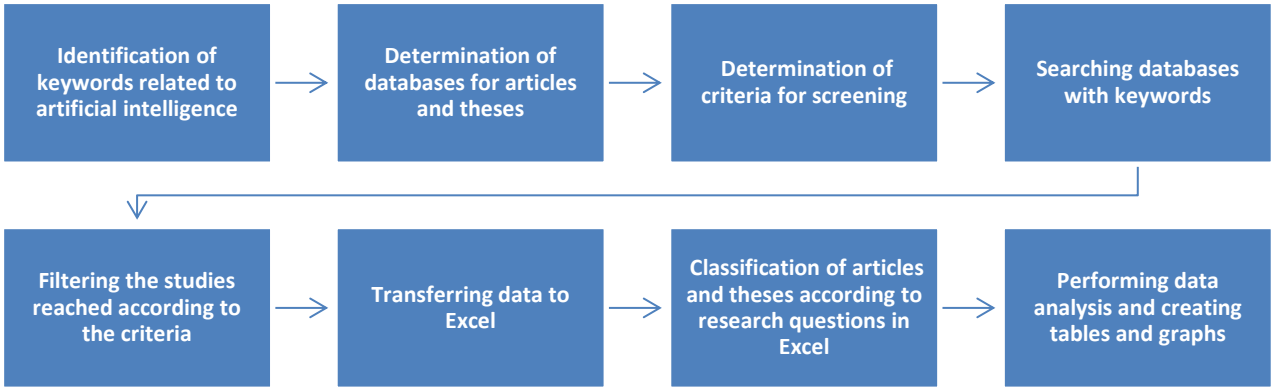
a. The studies to be examined should have been conducted between 2010 and 2023 (December).
b. The studies to be analysed should be conducted in Türkiye.
c. The studies should be published in 'Google Academic', 'DergiPark', 'YÖK National Thesis Centre' databases and should be open to access.

Fourthly, the studies to be analysed should contain the keywords related to 'science education' and 'artificial intelligence' or artificial intelligence.

A search was conducted for the keywords 'artificial intelligence' and 'science education' and 'artificial intelligence in education' in Google Scholar, yielding a total of '285' results. A further '50' results were obtained from the National Thesis Centre. The keywords 'artificial intelligence in education' and 'science education' were searched together in DergiPark, yielding a total of 2043 results. The remaining keywords, including 'artificial neural networks', 'deep learning', 'fuzzy logic', 'educational interface', 'machine learning', 'natural language processing', 'data mining', 'image processing', 'expert systems', 'robotic coding' and 'pattern recognition', were searched individually in the databases, with some limitations, and the articles and theses deemed appropriate were included in the study.

After an initial search of the databases, 77 studies were considered suitable for review. However, 42 studies were excluded because they did not meet the criteria in terms of their relationship to science education and AI. In this study, a total of 35 studies, 17 dissertations and 18 articles, were subjected to descriptive content analysis. The data collection and analysis process of the study is shown in Figure 1.

Figure 1. *Data Collection and Analysis Process of the Study*



2.2. Analysis of Data

In the present study, an analysis of the extant literature on science education and artificial intelligence was conducted through the utilisation of descriptive content analysis. The collected data was systematically and descriptively visualised and explained through the use of various tables and graphs. The objective of descriptive content analysis is to elucidate subsequent studies and to reveal the prevailing subject trends (Ültay et al., 2021).

In this study, the 'Article/Thesis Classification Data Entry Form' developed by the researcher was utilised to categorise the studies obtained from articles and postgraduate theses and to facilitate their entry into Excel for analysis. Within this form, the name, author, year of publication, type, journal/university where they were published, research design and method, data collection tools, sampling method, sample size, distribution of keywords used, and artificial intelligence methods and applications used were examined under 10 titles. The data obtained during the analysis process were classified by transferring them to an Excel file according to the 10 categories determined, and the data close to each other were transformed and handled under common headings in the Excel table. Then, the findings of the study were obtained with tables and graphs via Excel.
In line with this study, the studies on 'artificial intelligence', 'artificial intelligence in education' and related topics together with 'science education' between 2010-2023 were scanned using 'Google Scholar', 'DergiPark' and 'National Thesis Centre' databases and 35 studies (18 research articles and 17 postgraduate theses) were analysed. This study thus sought to analyse the general trends of research in the literature on the subject in question. Authors, publication year and title of the study for the studies analyzed are provided in Table 1 below.

Table 1. *Studies examined for Descriptive Content Analysis*

Author/s	Thesis/ Article	Year	Thesis/Article Name
Yılmaz	MT	2010	The effect of different educational interface agents that are used in educational software on the 8th grade primary school students? achievement, attitude and learning permanency for the science and technology course
Durmuş	PhD	2012	The effects of educational interface agent usage in virtual science and technology museum on the interests and successes of students
Koç Şenol	MT	2012	Science and technology laboratory applications supported by robotic: Robolab
Koç & Böyük	RA	2013	Technology based learning in science and technology education: robotic applications
Özdoğru	MT	2013	The effect of lego programme based science and technology education on the students' academic achievement, science process skills and their attitudes toward science and technology course for physical facts learning field
Ercan	MT	2016	Modelling factors affecting attitudes of 6,7 and 8th grade students towards science via artificial neural network method: Mus province sample
Akgün	PhD	2017	Modeling of Science and Technology Teaching Course Achievements of Elementary Teacher Candidates with Artificial Neural Networks
Schreglmann & Karakuş	RA	2017	The effect of educational interfaces on the critical thinking and the academic achievement
Aksu & Doğan	RA	2018	Comparison of learning methods used in data mining under different conditions
Yorgancı	MT	2018	Analysis of the relationship between attitudes towards teaching profession and academic achievement with artificial neural networks
Atasayar	MT	2019	The prediction of science success at High School Entrance Exam with artificial neural network
Benzer & Benzer	RA	2019	Determination of tendency of cyber bullying with artificial intelligence
Filiz	PhD	2019	Machine learning methods and an application on educational data: the trends in international mathematics and science study 2015 Turkey case
Irak Kürkan	MT	2019	Effects on the learning outcomes of science instruction based on socioscientific issues to the 7th grade students
Şimşek	MT	2019	Investigation of the effects of robotic coding application on science achievement and scientific process skills of 6th grade students in science course matter and heat unit
Yorgancı & Işık	RA	2019	The use of artificial neural networks in classifying the average grade of science teachers' candidates
Göktepe Yıldız & Göktepe Körpeoğlu	RA	2020	Examination of middle school students' interests in stem professions using educational data mining
Sağlam et al.	RA	2020	Investigation of emotional factors affecting PISA 2018 research with data mining methods
Sarı & Karaşahin	RA	2020	Computational thinking in science education: evaluating a teaching activity
Sanca et. al.	RA	2020	Why should fuzzy logic applications be used in science education?
Çam et al.	RA	2021	Determining teacher candidates' awareness of artificial intelligence technologies
İnal	MT	2021	Determining the perceptions of school administrators against artificial intelligence, data mining and big data concepts
Karataş & Ocak	RA	2021	Investigation of 5th grade students' achievement levels of mathematics, science and Turkish courses learning outcomes: a data mining study
Kesler	MT	2021	The effect of artificial intelligence system on the academic success of students in the unit of interaction of light with matter
Özen	MT	2021	Planning, implementing and evaluation of machine learning teaching for preservice teachers in STEM field
Uğuz et al.	RA	2021	The use of educational data mining in the evaluation of PISA 2018 scores of science
Ateş	PhD	2022	Planning internet of things (IoT) aided nano-STEM-GLASS activities and studying the implementation process
Bağır	MT	2022	Opinions of science teachers on the use of artificial intelligence in education
Çetintav et al.	RA	2022	Data mining analysis of the effect of technology use in the course on TIMMS 2019 results
Alan	PhD	2023	The analysis of e-learning settings, which are prepared on the basis of multiple intelligence domains determined by artificial intelligence in science instruction, as per different variables
Bayram & Çelik	RA	2023	A socio-science activity integrated with reasoning and entrepreneurial skills on artificial intelligence: pre-service science teachers' views
Çolak Yazıcı & Erkoç	RA	2023	Analysis of science group teachers' use of artificial intelligence in the distance education process
Güven & Sülün	RA	2023	Using of arduino assisted robotics coding activities in science teaching at the 5th grade of a secondary school
Soypak & Eskici	RA	2023	Examining research on robotic coding applications in high secondary school mathematics and science courses: a content analysis study
Yalçın Çelik & Çoban	RA	2023	Investigating the performance of AI-based chatbots in answering chemistry questions

PHD: PhD Thesis, MT: Master's Thesis, RA: Research Article

3. FINDINGS

In this study, the findings obtained from the relevant databases were examined in terms of the distribution of keywords in the publications obtained within the specified research questions, their types, sampling methods and sizes, data analysis methods, study group diversity, publication years, research methods and patterns, and data collection tools.

3.1 Distribution of Keywords Used in Studies on AI in Science Education

In the present study, the keywords employed in the obtained publications were initially examined and their frequencies were subsequently determined. The type and number of keywords vary in the examined studies. As a result of the content analysis, a total of 145 keywords were obtained in the examined publications. While organizing the keywords, one of the synonymous and near-synonymous keywords was determined and the others were converted to the determined word.

Following these coding procedures, the number of keywords examined was reduced to 82. The most frequently used word among the keywords in the study (f=10) was "science education". The keywords "artificial intelligence" (f=9) and "artificial neural network" (f=7) were the next most prevalent, followed by "data mining" (f=6), "science" (f=5), "robotics" (f=4), "academic success" (f=4) and "STEM" (f=4).

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After these codings, the number of keywords examined decreased to 82. The most frequently used word among the keywords in the study (f=10) was “science education”. It was followed by the keywords “artificial intelligence” (f=9) and “artificial neural network” (f=7), “data mining” (f=6), “science” (f=5), “robotics” (f=4), “academic success” (f=4) and “STEM” (f=4).

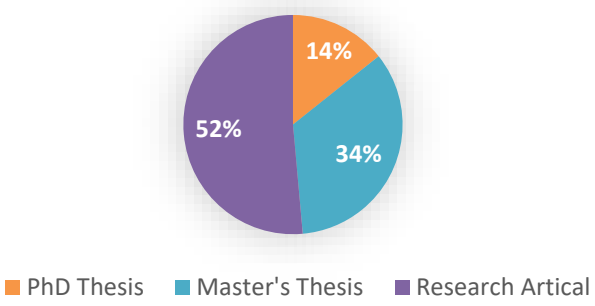
Other keywords used are; “WEKA, data analysis, three-stage model, distance education, attitude, TIMSS, technology-based learning, technology use, STEM-GLASS, interest in STEM professions, socio-scientific issues, socio-scientific reasoning, inquiry-based learning, chatbot, cyberbullying, classification algorithms, classification, classroom education, virtual museum, virtual science and technology museum, robotic coding, program development, PISA, attitude towards the teaching profession, teacher candidate, technology in education, learning method, middle school, focus group interview, internet of things (IoT), nanotechnology, nanoscience, happiness and success, motivation, mathematics and science success, mathematics education, mathematics success, machine learning, high school entrance exam, lego mindstorms NXT 2.0, laboratory, coding, chemistry education, decision trees, permanent learning, human-computer interaction, content analysis, interaction of light with matter, entrepreneurial skills, general grade point averages, awareness, e-learning, Industry 4.0, critical thinking, educational interface agent, education technology integration, artificial intelligence in education, big data in education, educational software, education, interdisciplinary science education, course outcomes, multiple intelligence theory, multi-layered perceptron model, study habits, fuzzy logic, Bloom's cognitive domain taxonomy, scientific process skills, scientific reasoning, computational thinking, fifth grade, sense of meaning, survey, 5E learning model.”

3.2. Distribution of Articles and Theses by Type

The second title of the study is the distribution of publications on artificial intelligence in science education according to research types (Figure 2). These studies are classified under three separate titles: "research article", "master's thesis" and "doctoral thesis". According to the data in Figure 3, the distribution and numbers of 35 studies published between 2010 and 2023 on science education and artificial intelligence according to research types are as follows; “research article” (f=18), “doctoral dissertation” (f=5) and “master’s theses” (f=12). These studies are mostly listed as “research article” (52%), followed by “master’s theses” (34%) and

"doctoral dissertation" (14%).

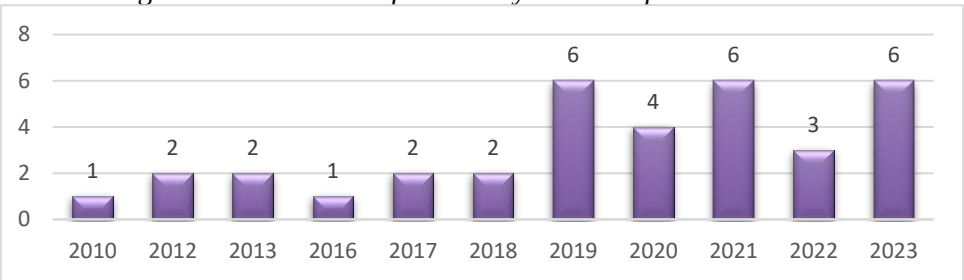
Figure 2. *Distribution of Studies in Terms of Article and Theses*



3.3. Distribution of Studies in Terms of Research/Publication Years

The figure showing the distribution of the studies on artificial intelligence in science education by year of publication and presentation is given in Figure 3.

Figure 3. *Distribution of Studies by research/publication Years*

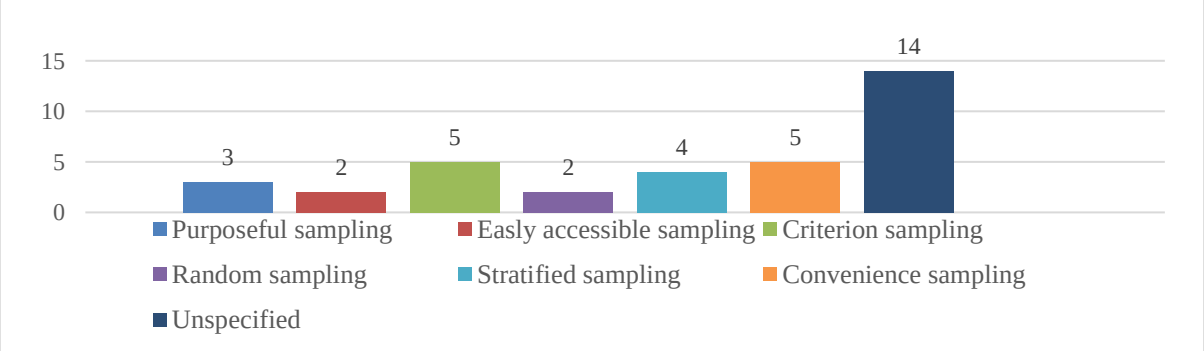


As illustrated in Figure 3, the distribution of publication years is as follows: the lowest number of studies was recorded in 2010 and 2016 (n = 1 each), followed by two studies in 2012, 2013, 201 In 2018, there was a notable increase to seven studies, followed by a decline in 2019 and 2021 to four and six studies, respectively. However, there was a resurgence in 2020 with seven studies, and a significant increase to eight studies in 2023. When the study rates of these 35 studies are examined by year, an increase is observed after 2018. Although this increase decreased in some years, it still maintained its upward trend in 2023. It is also seen that the difference is significant between 2010 and 2023, suggesting that the subject of artificial intelligence in science education is gradually becoming more prevalent.

3.4. Distribution of Studies in Terms of Sampling Method and Size

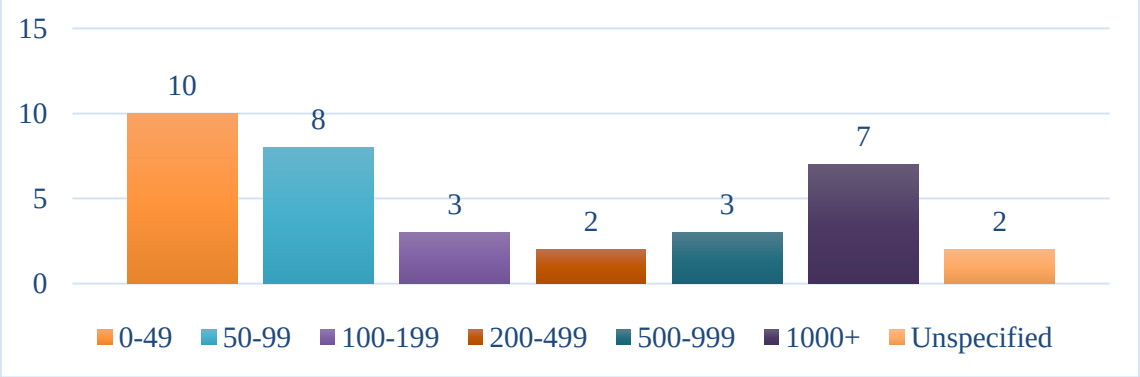
The findings regarding the sampling methods and sample sizes used in studies on Artificial Intelligence in Science Education were examined. The results of these examinations are presented in Figure 4 below.

Figure 4. *Distribution of Studies Conducted in Terms of Sampling Method*



As illustrated in Figure 4, the highest rate is observed in unspecified studies (f=14). While data on sample size and study groups is typically available in these studies, the sampling methods employed remain undetermined. When the studies are then ranked from high to low according to the number of times each sampling method was used, the most frequently used methods were "criterion sampling" (f=5), "convenience sampling" (f=5), "stratified sampling" (f=4), "purposeful sampling" (f=3), "easily accessible sampling" (f=2), and "random sampling" (f=2). This analysis indicates that "criterion sampling" emerges as the most favoured sampling method.

Figure 5. *Distribution of Studies in terms of Sample Sizes*

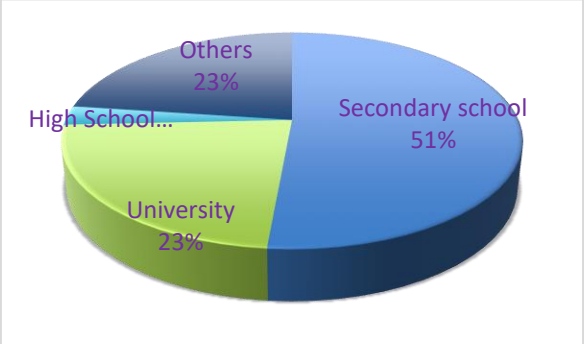


As illustrated in Figure 5, the data indicates that the majority of studies are concentrated within the "0-49" person range (f=10). When descending from the highest to the lowest, the following categories are observed: studies in the "50-99" person range (f=8), studies in the "1000+" person range (f=7), studies in the "100-199" person range (f=3), studies in the "500-999" person range (f=3), studies in the "200-499" person range (f=2). The number of samples is not specified, and the studies are limited to two. However, an analysis of these data suggests that the preferred sample size is in the range of 0-49 persons.

3.5. Distribution of Studies in Terms of Study Group

Within the scope of the study on AI in Science Education, 35 publications were examined by taking into account the teaching levels and the findings regarding the study groups are given in Figure 6.

Figure 6. *Distribution of Studies in Terms of Study Group*

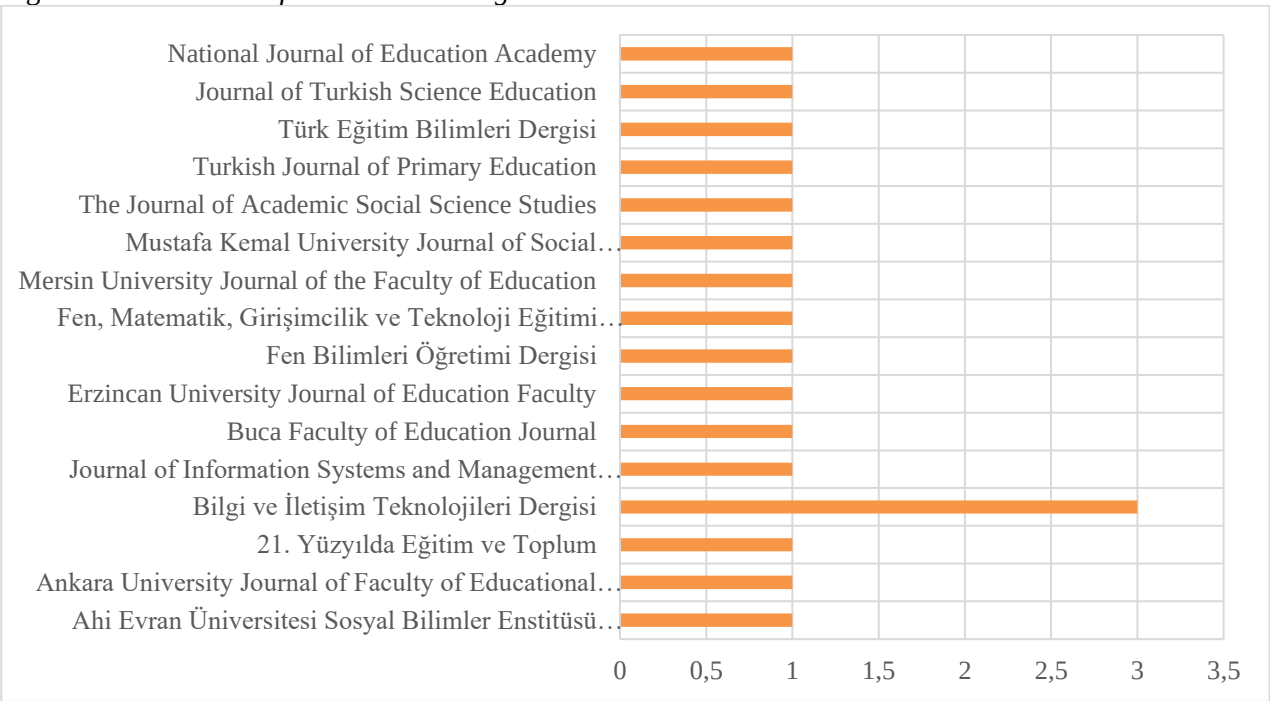


As illustrated in Figure 6, the majority of study groups are observed to be at the secondary school level (51%), with a smaller proportion at the university level (23%). The high school level is the least represented, accounting for 3% of the study groups. The remaining 23% of the study findings are distributed across various categories. The numerical equivalent of these rates is as follows: secondary school (f: 18), university (8), high school (1), and other (8). The remaining 23% (f = 8) encompasses occupational categories such as teachers and school administrators specialising in science and select other disciplines, in addition to content analysis studies. It can be posited that science education and studies of artificial intelligence are more favoured at the secondary school level.

3.6. Distribution of Studies According to Journals and Universities

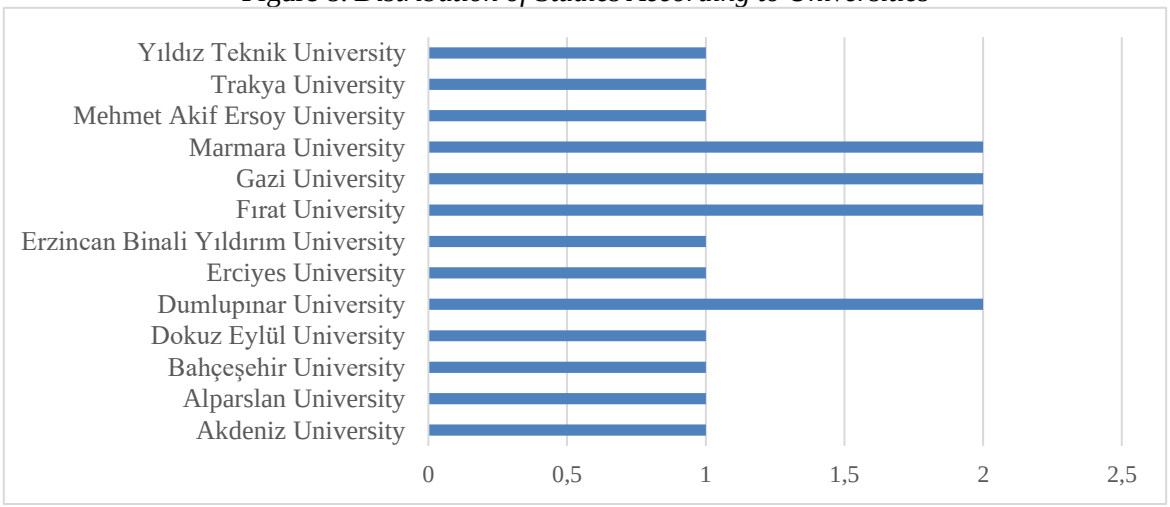
The findings regarding the journals in which studies on AI in science education were published are given in Figure 7, and the findings regarding universities are given in Figure 8.

Figure 7. *Distribution of Studies According to the Journals*



In the research conducted, a total of 35 studies were examined. Of these, 18 were research articles. The names of the journals in which these 18 studies were published, and their frequency of appearance, are given in Figure 13. According to this graph, the most studies were published in the Journal of Information and Communication Technologies (f=3). Of the remaining 15 studies, one was published in each of the journals specified in the graph.

Figure 8. *Distribution of Studies According to Universities*

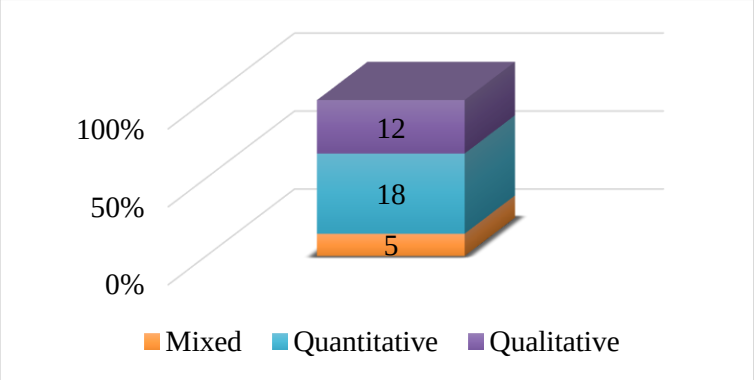


As illustrated in Figure 8, the data indicates the universities in which theses on artificial intelligence in science education were published. Of the 35 studies that were examined in the conducted research, 17 were master's (f=12) and doctoral (f=5) theses. The figure 9 shows a total of 13 different universities. The universities that have published the most studies are "Dumlupınar University", "Fırat University", "Gazi University" and "Marmara University" (each with two studies), while the remaining nine postgraduate theses are located at the aforementioned universities.

3.7. Distribution of Studies in Terms of Research Method and Design

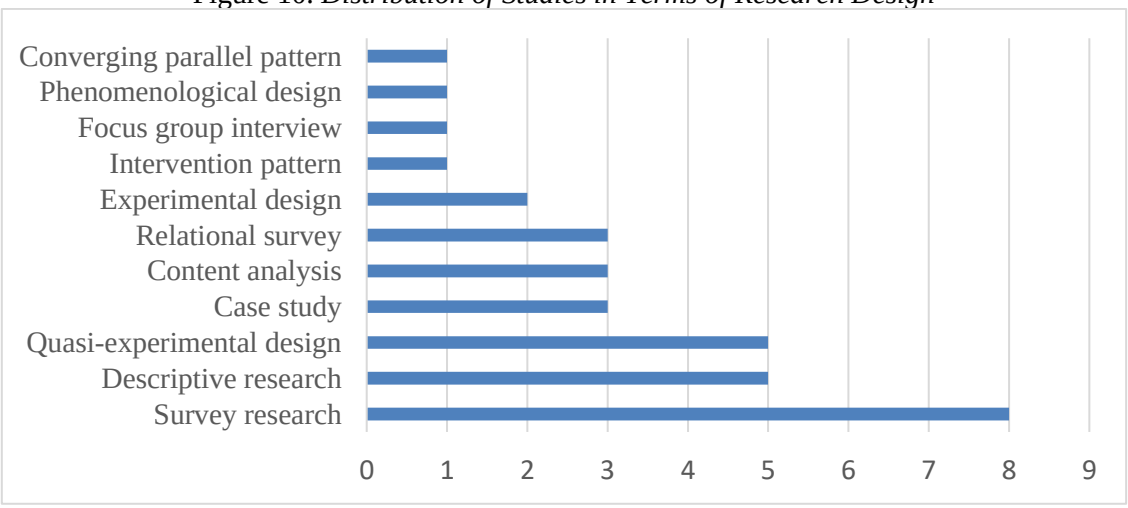
In consequence of the findings pertaining to the research methodologies employed in the analysed studies, it was ascertained that the most prevalent method was the quantitative research method. Moreover, the findings obtained from the studies demonstrated that the most favoured research design was survey research.

Figure 9. *Distribution of Studies in Terms of Research Method*



In the context of research conducted on the utilisation of artificial intelligence in the domain of science education, the graph in Figure 9 provides a comprehensive representation of the research methodologies employed in the studies. The graph reveals a total of 35 study methods, including 12 qualitative studies, namely descriptive research (f=4), case study (f=3), content analysis (f=3), focus group interview (f=1), and phenomenological design (f=1), and 18 quantitative studies, encompassing survey research (f=1), experimental design (f=2), relational survey design (f=3), regression analysis (f=1), survey research (f=6), quasi-experimental design (f=5)" and 5 mixed studies "explanatory design (f=1), triangulation design (f=1), multi-stage design (f=1), intervention design (f=1), convergent parallel design (f=1)".The studies with the highest rate among these studies are quantitative studies. This finding lends further credence to the notion that the quantitative research method is the most favoured approach in this field of enquiry.

Figure 10. *Distribution of Studies in Terms of Research Design*

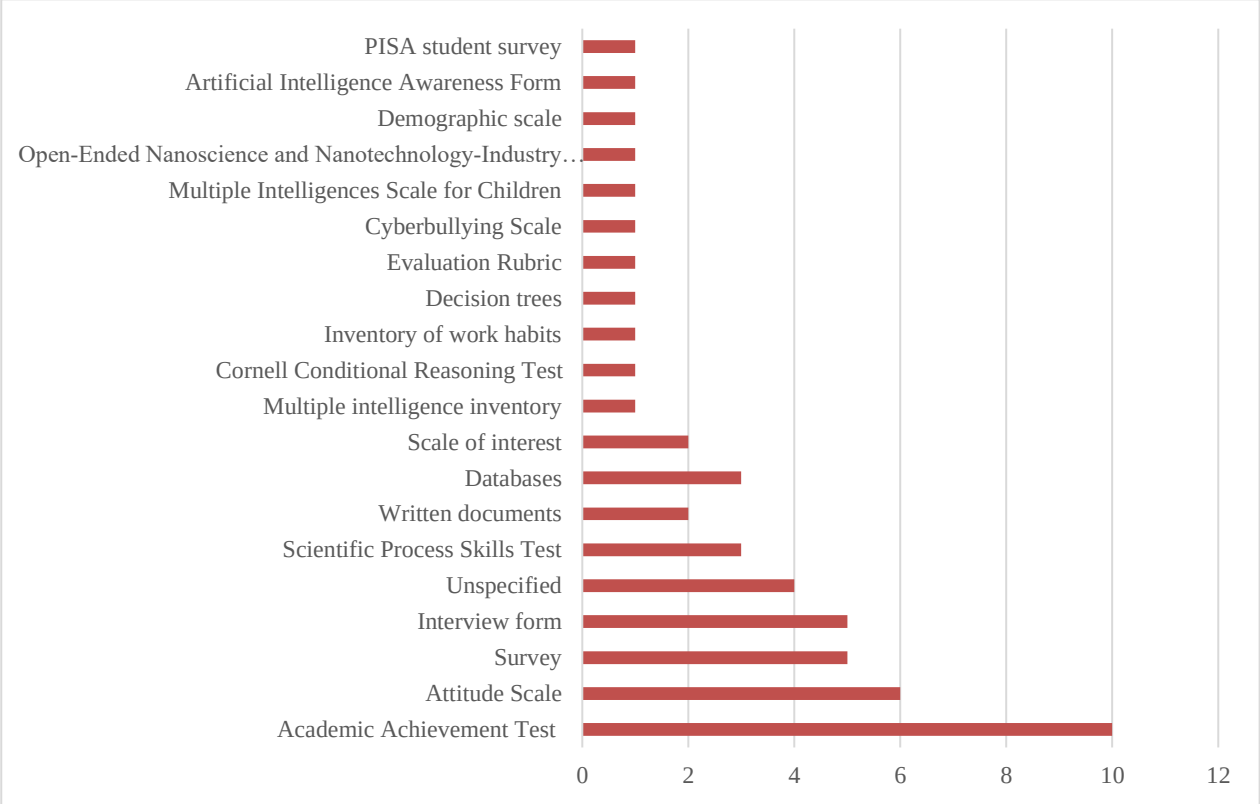


In the context of research conducted on the utilisation of artificial intelligence in the domain of science education, the graph in Figure 10 provides a comprehensive representation of the research designs and quantities employed in the studies. It is evident from the graph that the most prevalent design (f=8) is "survey research", followed by "descriptive design" and "quasi-experimental design" with five studies. The third most popular design in the initial three categories is "relational survey design", "content analysis" and "case study", with three studies each. Two studies each were conducted on "experimental design" and "descriptive research", while one study each was conducted on the remaining nine least preferred research designs.

3.8. Distribution of Studies in terms of Data Collection Tools

A thorough examination of Figure 11 reveals that the most frequently employed data collection instrument in the studies is the "academic achievement test" (f=10). Additionally, it is observed that the "attitude scale", "questionnaire", "written documents", "interview form", "databases", "scientific process skills test" and tools are among the most widely used data collection tools. The category of "not specified" (f=4) encompasses studies that do not specify a particular data collection tool, while studies employing tools from the "written documents, semi-structured interview form, interest scale" categories are also identified.

Figure 11. *Distribution of Studies in Terms of Study Group*

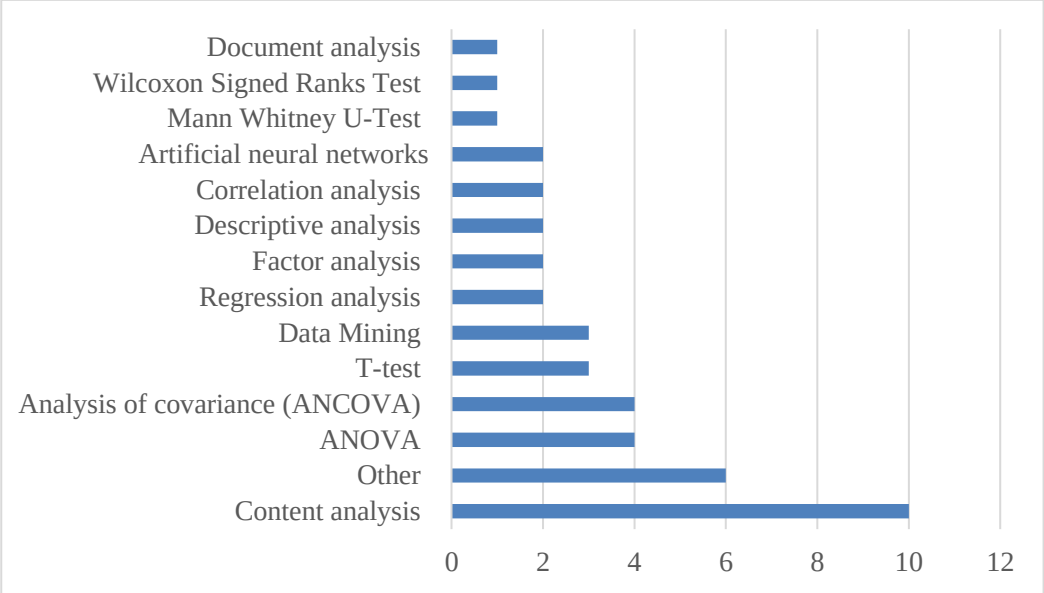


The least preferred data collection tools are said to be "decision trees, PISA student survey, artificial intelligence awareness form, multiple intelligence scale for children, demographic scale, open-ended nanoscience and nanotechnology-industry 4.0 form, Cornell conditional reasoning test, cyberbullying scale, Evaluation rubric", with one instance of each tool being used in the studies examined. Consequently, the total number of data collection tools utilised in the examined studies exceeds 50 (f=51). It is evident that the number and variety of data collection tools employed vary significantly.

3.9. Distribution of Studies in terms of Data Analysis Methods

As demonstrated in Figure 12, upon examination of the studies according to their data analysis methods, it was found that a variety of approaches were employed, with the number and variety of analysis methods used varying. The most frequently utilised data analysis method in the studies was identified as 'content analysis' (f=10), followed by 'ANOVA' (f=4) and 'ANCOVA' (f=4) methods, with four studies each. The least frequently employed data analysis techniques were identified as the 'Man Whitney U-Test', 'Wilcoxon Signed Ranks Test' and 'Document Analysis', each employed in a single study. The 'Other' category, encompassing six distinct methods, was also analysed. These results indicate that the 'content analysis' method is the most prevalent in the field of artificial intelligence in science education.

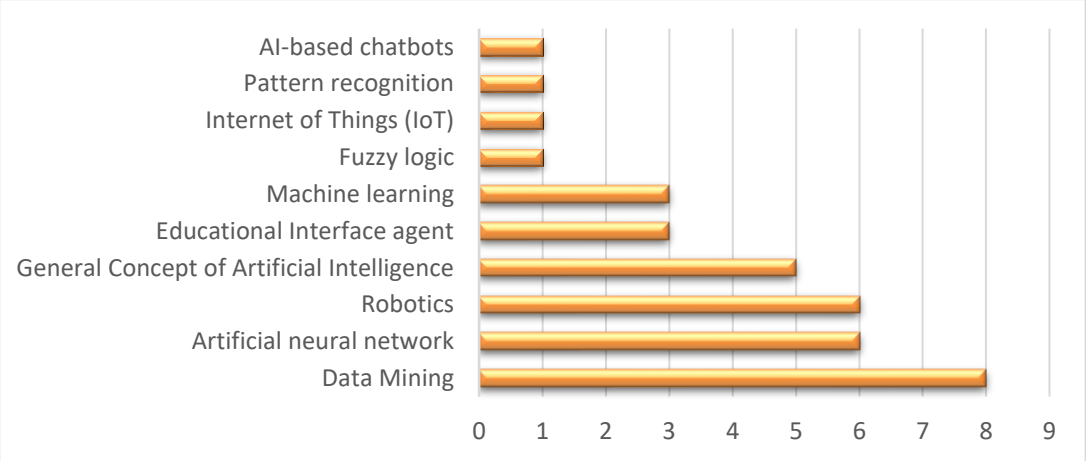
Figure 12. *Distribution of Studies in terms of Data Analysis Methods*



3.10. Distribution of Artificial Intelligence Methods, Techniques and Applications Used in Studies

Figure 13 provides a visual representation of the findings concerning the artificial intelligence methods, techniques and applications utilised in the studies and regarded as subjects. The graph illustrates the frequency with which artificial intelligence techniques and applications are preferred in the studies examined. It is evident that the most frequently employed method is "data mining" (f=8). The "artificial neural network" method (f=6) and "robotics" (f=6) were the next most prevalent methods, followed by "general artificial intelligence concept" (f=5), "machine learning" (f=3) and "educational interface agent" (f=3). Conversely, "fuzzy logic" (f=1), "internet of things" (f=1), "pattern recognition" (f=1) and "artificial intelligence-based chatbots" (f=1) were identified as the least preferred techniques and applications.

Figure 13. *Distribution of Artificial Intelligence in Terms of Methods, Techniques and Applications*



4. CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This descriptive content analysis study examined existing postgraduate theses and articles in the fields of artificial intelligence and science education in Turkey between 2010 and 2023. The aim of the review was to reveal the general trends of research on specific issues. A total of 35 studies were analysed, including 12 master's theses, 5 doctoral theses and 18 research articles.

The keywords "artificial intelligence" and "science education", "artificial neural networks", "deep learning", "fuzzy logic", "educational interface", "machine learning", "natural language processing", "data mining", "image processing", "expert systems", "robotic coding" and "pattern recognition" were identified. The "Google Academic", "National Thesis Center" and "DergiPark" databases were searched for studies addressing the subject in Türkiye between the years 2010-2023.

The Artificial Intelligence Applications Course Curriculum for secondary school students, published by the Ministry of National Education (2023a), encompasses seven distinct artificial intelligence concepts: machine learning and pattern recognition, artificial neural networks, fuzzy logic, developing sample projects in a block-based environment, data mining, image processing. These concepts are incorporated into the curriculum and are subject to instruction. The keywords examined and presented in line with our study are numerous and appear to include all of these concepts. In addition, different artificial intelligence concepts such as "educational interface agent", "robotics" and "decision trees" were also encountered. Based on this, it can be said that our study includes concepts taught at the secondary school level.

A study was conducted by Akdeniz and Özdinç (2021) in which the literature was examined with a view to identifying artificial intelligence techniques in the context of the keywords "fuzzy logic, artificial neural networks, intelligent agents, expert systems and intelligent tut oring systems (IFS) and artificial intelligence (General)" in the "National Thesis Center", "DergiPark" and "Google Scholar" databases between the years 1999-2018 and descriptive content analysis was performed. In the study conducted by Kavut (2022), the focus was on examining authorised postgraduate theses on artificial intelligence that had been published in the National Thesis Center of the Council of Higher Education in Turkey between the years 2019-2021. This was achieved by employing the content analysis method. Concurrently, Meço and Coştu (2022) undertook a separate study, which involved scanning the studies on the same subject with the keyword "artificial intelligence in education" conducted in Turkey between 2017-2021 from the "Google Academic" and "Higher Education Council (YÖK) National Thesis Center" databases. In a similar vein, Tekin (2023) examined the articles and postgraduate theses conducted in Türkiye in 2023 and prior to that on the subject of "artificial intelligence in education". A total of 39 articles and theses were determined and examined from the "ULAKBİM TR Index" and "YÖK National Thesis Center" databases. Güzey et al. (2023) examined the articles using the terms "artificial intelligence in education" in the "education & education research" category of the Web of Science website between 2019-2021 by utilizing artificial intelligence techniques in education.

As demonstrated by these results, the majority of Turkish studies utilised conventional keywords and databases. Nevertheless, there are distinctive elements that set this study apart from others. Primarily, our study is situated within the domain of "science education", and we have concurrently addressed the keywords "artificial intelligence" in education, in addition to artificial intelligence methods, techniques and applications.

While there is an absence of analogous studies in our country concerning the literature review in the domain of science education and artificial intelligence, studies conducted on this subject are identified when examining the literature outside Turkey. In the research conducted by Jia, Sun & Looi (2023) in the domain of science education between 2013 and 2023, 76 studies were accessed via the "Web of Science" and "Scopus" databases using keywords such as " artificial intelligence in science education", "artificial intelligence", "data mining", "machine learning", "algorithm", "expert system", "intelligent education system", "robot", "personalized learning", "recommended system" and bibliometric and content analyses of these data were performed. It should be noted that the choice of databases, inclusion of studies from Turkey, selection of keywords in Turkish, incorporation of different keywords and utilisation of varied analysis methods have contributed to the diversity of this study. The findings have provided insights into the trends in studies examining artificial intelligence in the context of science education in Türkiye.

A subsequent examination of the findings has revealed that the majority of studies conducted on artificial intelligence were of a quantitative nature. Güzey et al. (2023) also stated that their research, which examined the content analyses of studies on artificial intelligence in education, focused predominantly on quantitative studies.

A review of studies on artificial intelligence and science education reveals a balanced prevalence of research articles and graduate theses. This suggests a high level of interest in the field, which is reflected in its extensive publication across various academic disciplines. The analysis methods employed in these studies encompass conventional approaches such as content analysis and ANOVA, along with more advanced techniques like data mining and artificial neural networks. This finding suggests that the field of artificial intelligence is both innovative and open to diverse methodological approaches. The analysis of extant literature reveals a plethora of applications and studies in the domain of artificial intelligence, with implications for science education. The present study employed a descriptive content analysis of graduate theses and articles from the scientific literature on artificial intelligence and science education. The study's findings are expected to contribute to the extant literature and to researchers who wish to conduct studies in this field.

4.1. Recommendations

This study, and similar content analysis studies, can be conducted in different areas of education instead of "science education" based on existing studies in the literature. The subject can also be studied using different keywords that include artificial intelligence applications, methods or techniques. In addition, different studies can be put forward that include science education topics as well as "artificial intelligence" and its application areas, which are increasingly being studied. A review of studies conducted in Turkey indicates a paucity of research on the application of AI in the domain of science education. However, experimental studies in this area are possible. Furthermore, it is recommended that researchers explore the potential of artificial intelligence in science education programmes.

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