



Examination of studies on artificial intelligence and chatbots in the context of secondary school science course: content analysis

Taner Yılmaz* 

Yozgat Bozok University, Çekerek Fuat Oktay Vocational School of Health Services, Department of Medical Services and Techniques, Medical Promotion and Marketing Program, Yozgat, Türkiye, ttaneryilmaz@gmail.com

İlbilge Dökme 

Gazi University, Department of Mathematics and Science Education, Ankara, Türkiye, ilbilgedokme@gazi.edu.tr

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* Corresponding Author

Abstract:

This study aims to investigate the applications of artificial intelligence and chatbots in secondary school science lessons through descriptive content analysis. Using a qualitative case study approach, 20 theses from YÖKTEZ database and 10 international articles from Google Scholar were analysed, focusing on chatbots in science education. The results of the analysis revealed a notable increase in AI and chatbot-related theses between 2012 and 2023, especially in the last two years, highlighting the growing interest in e-learning and AI in STEM fields. Positive effects on student and teacher attitudes towards STEM education have been widely reported. However, besides the limited number of international studies, the discovery of only one secondary school thesis on chatbots unrelated to Science in Türkiye points to a significant research gap in AI and chatbot integration into Science education. Addressing this gap may improve the application of AI and chatbot technologies in science teaching and reveal the need for further research to explore their potential benefits and applications in educational settings.

Keywords: Artificial Intelligence, Chatbot, Science, Descriptive content analysis, Education

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1. INTRODUCTION

Countries adopting the 21st-century vision expect teachers and students to be knowledgeable and responsible digital citizens. Kusal et al. emphasize that technology can support social development with the combination of human intelligence and artificial intelligence [1]. Educational activities are carried out with a constructivist approach that focuses on student's ability to apply knowledge. Coiera emphasizes the importance of thinking machines in education and states the necessity of redefining educational environments [2].

Popenici and Kerr and Hwang et al. define AI applications in education as technologies that support learning through various tools such as chatbots and automated assessment systems [3][4]. Artificial intelligence is leading the transformation of education by improving educational materials and providing new learning methods [5].

Science education aims to raise competent individuals who can apply science to daily life. Building a solid scientific foundation at the secondary school level contributes to students' lifelong success. Chang, Park & Park, and other studies highlight the potential of artificial intelligence and chatbots in science education to respond to students' individual needs and receive personalized feedback [6]. These technologies can make science learning more effective and student-centered.

In the literature, there are several examples of the positive effects of chatbots in secondary school science education. For example, Lin & Ye and Rosmiati, Sujana & Aeni show that chatbots are effective learning tools for students [7][8]. These studies suggest that chatbots should play more active pedagogical roles in science learning.

This study aims to examine the studies on the use of Artificial Intelligence (AI) and Chatbot technologies in secondary school science courses through a descriptive content analysis. Although the potential of AI and chatbots in education has attracted great attention, research on these technologies, especially in the context of secondary school science, is limited. In order to overcome this deficiency, it is aimed to provide a perspective on how AI and chatbots can be used effectively in science courses by collecting, summarising and analysing existing studies. It is also aimed to provide inspiration for innovative applications and strategies in science courses by expanding the literature to include findings on the use of these technologies in different courses. This comprehensive review aims to develop a comprehensive understanding of the integration of AI and chatbot technologies in secondary school science teaching and to provide practical recommendations. As a result, this study aims to provide general recommendations to help educators and researchers to use AI and chatbots more consciously and effectively.

The literature analysed in this study is divided into two main categories: domestic theses and foreign articles. The questions addressing the sub-problems specific to the research were organised in accordance with this distinction. Answers to the following questions were sought through the theses and articles analysed in this study:

- 1. How is the distribution of theses in Türkiye and articles abroad according to years and types?*
- 2. Which main research themes do these theses and articles address and what kind of objectives do they set?*
- 3. Which study groups were included in the studies and which research methodologies were used?*
- 4. Which data collection tools were preferred in these studies and which data analysis methods were applied?*
- 5. What are the results reached in these studies?*

2. METHODOLOGY

This research was conducted using a case study design, which is a qualitative research design that makes it possible to examine perceptions and events in their natural environments in a holistic and realistic way by using various qualitative data collection techniques such as observation, interview and document analysis [9] and defining situations and themes related to the situation [10]. This approach allowed the research to systematically examine the existing studies on artificial intelligence and chatbots in the context of secondary school science course in terms of various variables.

In this study, criterion sampling method, which is one of the purposive sampling methods, was used for the selection of the analysed studies. This method was preferred in order to facilitate the systematic selection and examination of the studies that best meet the specific criteria. According to Marshall & Rossman, criterion sampling is the process of selecting and examining cases that meet the criteria that the researcher has predetermined or already exists [11]. The basis of the criterion sampling method, as stated by Patton, is the detailed examination and evaluation of cases that meet predetermined important criteria or criteria [12]. These criteria may be specially created or predetermined by the researcher. This method is used to provide a systematic analysis of the selected cases. In this context, the criteria taken as basis while determining the sample of the study were determined as "Theses conducted for secondary schools in Türkiye are related to artificial intelligence and chatbots" and "Studies conducted abroad consist of articles focusing on the use of artificial intelligence and chatbots at secondary school level".

In the data collection process, the document analysis method was used. Bowen defines this method as a systematic examination or evaluation of both printed and electronic (computer-based and published via internet) materials [13]. For this purpose, firstly, it was tried to obtain the documents belonging to the theses conducted in Türkiye in accordance with the purpose of the research. In Türkiye, studies using chatbots in the field of education are quite limited. For this reason, the literature study for the studies conducted in Türkiye was conducted by considering artificial intelligence and chatbots together. In this context, the literature review was conducted using the YÖKTEZ Centre database, which contains academic studies of the Higher Education Institution (YÖK). YÖKTEZ Centre database was preferred because it is thought that it will help to see the academic level of studies on artificial intelligence and chatbots in the field of education in Türkiye. The studies were conducted using the keywords "artificial intelligence", "artificial intelligence" and "chatbot", and as a result of the search, 20 studies conducted for secondary schools under the subject heading "education and training" were found and included in the study. At the same time, documents related to articles conducted abroad were also scanned. There is a large foreign literature that focuses on the use of artificial intelligence and chatbots in education. In this study, a literature review was conducted to identify studies that examine the use of chatbots for educational purposes and address the middle school level. As a result of the searches using Google Scholar search engine with the keywords "chatbot", "chatbots in education", "chatbots in middle schools", it was seen that the majority of the studies focused on high school and university-level education, while the number of studies at the middle school level was limited. In the light of the findings, high school and university-level studies were excluded from this study and only middle school-level studies were included. In this context, 10 articles on the use of chatbots for educational purposes in secondary schools were analyzed in this study.

This research was carried out by using descriptive content analysis technique to classify the studies in a certain field according to predetermined criteria and to determine general trends. Descriptive content analysis is a method that aims to systematically analyse qualitative and quantitative studies and to reveal general trends [14][15][16]. While difficulties may arise when the number of publications is high, this process may become easier when there are few publications [17]. In this study, descriptive content analysis method was adopted to thematically summarise the existing studies on artificial intelligence and chatbots in the context of secondary school science courses and to evaluate their trends. While conducting this analysis, firstly, 20 theses conducted in Türkiye and 10 articles conducted abroad were

analysed under 8 themes as "type and year", "subject", "purpose", "study group", "method", "data collection tools", "types of analysis" and "results" within the framework of the research questions. The research data were first coded according to the determined themes, and then the categories and themes were shaped by combining similar codes. After the analysis process was completed, the researchers mutually evaluated the results of the analyses and a common understanding was reached on the data and finalised.

This research followed a carefully designed methodology to ensure reliability and accuracy. The data collection and review processes were thoroughly documented, archived, and recorded in a spreadsheet to ensure transparency and reproducibility of the study. The transparent and consistent coding procedures used in the analysis phase ensured that the categories created were clear enough for similar conclusions to be reached by different researchers. During the research process, the coding and categorization processes were periodically reviewed, and inter-researcher agreement was achieved at a high rate of 93% using the formula suggested by Miles and Huberman [18]. Quality assurance was ensured based on the criteria proposed by Guba and Lincoln, and each stage of the research was explained in detail to provide the necessary transparency and applicability for researchers who will conduct similar studies in the future [19]. The research results were analyzed by two independent evaluators who are experts on the subject, and improvements were made with the feedback obtained in this process. The findings were presented with direct quotations, and the data obtained were verified by comparing them with raw data in order to increase the reliability of the study. All processes of the research were reported in detail so that future researchers can re-do the study. This comprehensive approach improved the quality of the research and contributed to the reliability and accuracy of the findings.

Since this study does not fall into the category of research requiring ethics committee approval, such permission was not obtained. However, in all stages of the study, scientific integrity and publication ethics were followed. In this context, actions such as adding non-existent data or distorting existing data were avoided, and the research was based on real and accurate data. The reporting process was carried out meticulously by avoiding unethical behaviors such as plagiarism. The results obtained were shared only through a single medium, not for multiple publications. Since no external support was received during the realization of the research, there is no information about financial support in the report. The principles regarding authorship rights have been prioritised and necessary explanations have been made in this regard. All of the researchers contributed equally to the creation of the article. There is no conflict of interest between the authors.

3. RESULTS AND DISCUSSION

A total of 30 studies, 20 theses, and 10 articles, were selected in accordance with the criteria determined within the framework of the research. These studies were analyzed according to the research questions and the findings were presented in an orderly sequence using various figures and tables.

3.1. How is the distribution of theses in Türkiye and articles abroad according to years and types?

The theses addressed within the framework of the research questions were analyzed under the theme of "type and years" in terms of the distribution of theses according to type and years. The distribution of theses by type and years is shown in Figure 1.

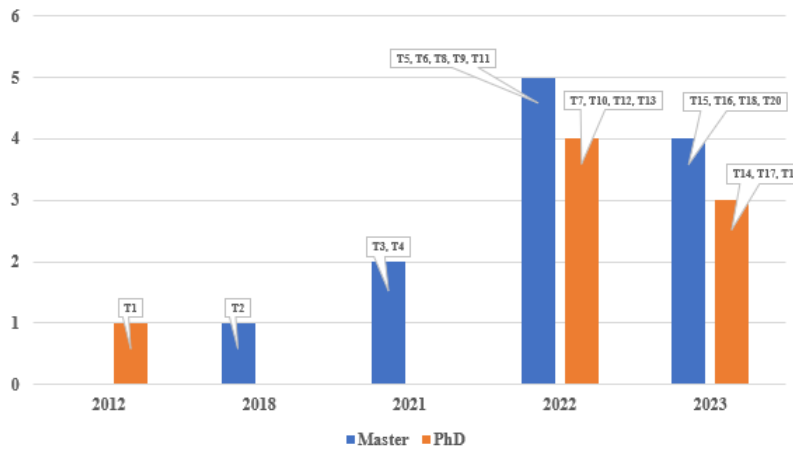


Figure 1 Publication years and types of theses

When Figure 1 is examined, a total of two theses, one master's thesis and one doctoral thesis, were published in 2012. In 2018, only one doctoral thesis was published. By 2021, two master's theses contributed to the academic field. In the following year, 2022, there was a noticeable increase in the number of master's theses and five master's theses and two doctoral theses were published. In 2023, a total of seven theses, three master's theses, and four doctoral theses, were published. The findings obtained show that there is a fluctuating trend in the number of master's and doctoral theses published in the period under study, and an increasing trend is observed especially in 2022 and 2023.

The articles addressed within the framework of the research questions were analysed under the theme of "years" in terms of the distribution of articles according to years. The distribution of articles according to years is shown in Figure 2.

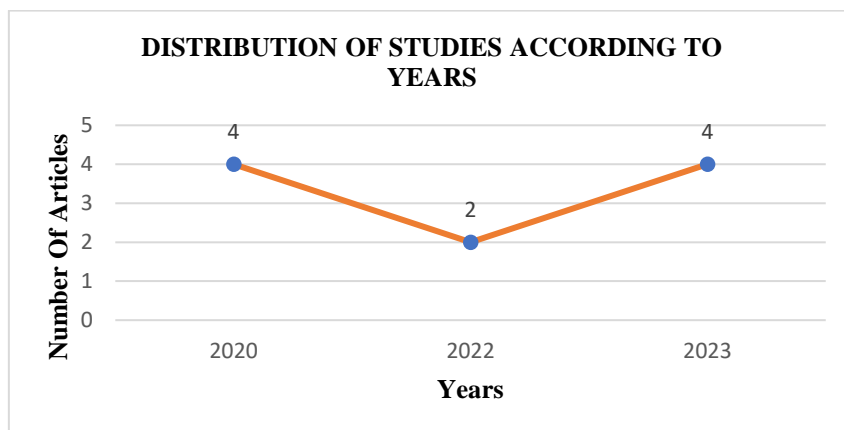


Figure 2 Distribution of Articles by Year

Looking at the graph in Figure 2, it is seen that the number of studies on chatbots for secondary schools was 4 in 2020. After 2020, it is seen that the number of studies decreased, 2 studies were conducted in 2022 and the number of studies increased to 4 in 2023. As a result, these data show that the use of chatbots in education for secondary schools fluctuates over time and that research in this field has increased and decreased over the years.

3.2. Which main research themes do these theses and articles address and what kind of objectives do they set?

The theses addressed within the framework of the research questions were analyzed under the theme of "topics" and categorized into categories and codes. This categorization was made according to the

main foci of the theses and each category groups the studies on related topics. The distribution of the theses categorized according to the codes and thesis topics is presented in Table 1 in detail.

Table 1 Topics of the theses

Category	Code	Thesis Subjects	Theses
Technology Integration	E-Learning and Learning Analytics	Analysing learning styles and strategies used in e-learning environment with web usage mining	[20]
		Planning, implementation and evaluation of machine learning instruction developed for pre-service teachers in STEM field	[21]
		The effect of using artificial intelligence technologies in education on student achievement: A meta-analysis	[22]
		The effect of the course plan and contents developed for teaching artificial intelligence in schools on students' metacognitive behaviours	[23]
	Artificial Intelligence Applications	The use of chatbots as an example of artificial intelligence application in social studies teaching	[24]
		Investigating the effect of e-learning environments prepared according to multiple intelligence areas determined by artificial intelligence in science teaching on secondary school students' academic achievement, science attitudes and technology attitudes	[25]
		Meta-analysis study on artificial intelligence applications in education	[26]
		Artificial intelligence awareness level scale for teachers: Reliability and validity study	[27]
		Science teachers' views on the use of artificial intelligence in education	[28]
		Determining the awareness levels of prospective teachers about the concept of artificial intelligence and artificial intelligence applications	[29]
Student Achievement and Attitudes	Academic Achievement and Attitudes	Analysing the relationship between attitude towards teaching profession and academic achievement with artificial neural networks	[30]
		The effect of educational digital games coded and designed by students on social studies teaching	[31]
		The effect of artificial intelligence education content developed for secondary school students on artificial intelligence literacy	[32]
		Predicting the correct numbers of LGS History of Turkish Revolution and Kemalism substest with artificial intelligence methods	[33]
Training Programmes and Evaluations	National and International Assessments	Examining the mother tongue teaching programmes of successful countries in PISA and Türkiye and analysing the programmes with ANFIS	[34]
		Investigation of science teachers' views on the use of artificial intelligence-supported technologies in science teaching	[35]
	Training Content and Strategies	Determination of pre-service science teachers' grounded mental models about energy and classification of them with deep neural networks	[36]
		Investigation of the effectiveness of course materials prepared with REACT strategy for science subjects	[37]
		Analysing the use of artificial intelligence in art activity and education, revealing how and where it is used and evaluating its effects	[38]
Innovative and Cultural Practices	Artificial Intelligence in Art and Culture	Development of an artificial intelligence literacy curriculum for secondary school students	[39]

According to the findings in Table 1, in the category of "Technology Integration", various topics such as learning styles and strategies of e-learning environments, web usage mining techniques, machine learning in STEM education, the role of artificial intelligence in education, the use of chatbots in social

studies teaching, and the design of e-learning environments based on multiple intelligence theory were examined. In the category of "Teachers and Teacher Candidates", awareness and attitudes towards artificial intelligence and the level of knowledge of teacher candidates about artificial intelligence were discussed. In the category of "Student Achievement and Attitudes", the effect of educational digital games, the effects of artificial intelligence educational content on literacy, and the relationship between attitude towards teaching profession and academic achievement were examined. The category of "Educational Programmes and Evaluations" includes studies on national and international evaluations, artificial intelligence-supported educational technologies and the effectiveness of course materials. In the "Innovative and Cultural Applications" category, creative uses of artificial intelligence in art and education and artificial intelligence literacy programmes designed for secondary school students were investigated.

The articles addressed within the framework of the research questions were analysed under the theme of "topics" and categorised into categories and codes. This categorisation was made according to the main foci of the articles and each category groups the studies on related topics. The distribution of the articles categorised according to the codes and article topics is presented in Table 2 in detail.

Table 2 Topics of articles

Category	Code	Subjects of Articles	Articles
Education and Teaching Methods	Life skills for adolescents	A chatbot-based coaching intervention to improve life skills for adolescents: a pilot study	[40]
	EFL students' speaking competence	The effects of voice-based artificial intelligence chatbots on Korean EFL middle school students' speaking competence and affective domains	[41]
	Science concepts and critical thinking	The Effectiveness of Using a Cognitive Style-Based Chatbot in Developing Science Concepts and Critical Thinking Skills in Preparatory School Students	[42]
	Biology learning performance	Development of an Educational Chatbot System to Improve Students' Biology Learning Performance	[43]
	Teaching the rotation of the earth and cyclic motion	Development of 6th grade students' chatbot learning media on the rotation and cyclic motion of the earth	[44]
Technology Supported Communication and Interaction	Student-Teacher interaction	Supporting student-teacher interaction through a chatbot	[45]
	Interaction of children with chatbot	Analysing children's interaction with an artificial intelligence chatbot and its effect on their interest in reading	[46]
	Scientific enquiry and chatbot use	Using an AI chatbot in scientific enquiry: Focusing on a Guided Inquiry activity using InquiryBot	[47]
Attitude and Behavioural Changes	Changes in anti-bullying attitudes	Interactive computer technology in anti-bullying education: Effects of the role of chatbot on K-12 students' attitude change towards bullying problems	[48]
Teachers' Acceptance of Technology	Acceptance of artificial intelligence in science teaching	Acceptance of artificial intelligence in science teaching: Science teachers' perspective	[49]

In Table 2, articles examining the impact of chatbot technologies on education and training methods are presented according to different categories. The Education and Training Methods category covers topics ranging from developing young people's life skills to improving biology learning performance. The Technology Supported Communication and Interaction category includes applications from teacher-student interactions to scientific inquiry processes. The Attitude and Behavior Changes and Teachers' Acceptance of Technology categories focus on attitude changes towards social issues in education and teachers' views on the acceptance of AI technologies in education, respectively.

The theses examined within the framework of the research questions were analysed under the theme of "aims" and divided into sub-themes, categories and codes. The categories and codes that emerged from the examination of the aims determined in the theses are summarised in Table 2 according to the relevant sub-themes.

Table 3 Aims of theses

Sub Theme	Category	Code	Theses
Technological Applications and Approaches in Education	E-Learning and Learning Styles	Learning Styles and strategies in e-learning environments	[20]
	Artificial Intelligence and Teacher Education	Prospective teachers' attitudes towards the profession and the use of ANN	[30]
		Teaching machine learning in STEM education	[21]
	Artificial Intelligence Awareness and Academic Performance	Measurement of teachers' awareness of artificial intelligence	[27]
		The effects of artificial intelligence technologies on student achievement	[22]
Educational Evaluation Methods and Content Development	Teacher Opinions and Training Contents	Teachers' views on the use of artificial intelligence in education	[28]
		LGS performance prediction	[33]
		Use of coding and educational games in education	[31]
		Analysis and comparison of international education programmes	[34]
		The use of artificial intelligence technologies in education and teachers' opinions	[35]
Innovative Educational Strategies and Tools	Use of Artificial Intelligence in Education	Artificial intelligence curriculum design and evaluation	[23]
		Analysing the use of chatbot in education	[24]
		Analysing e-learning environments in terms of multiple intelligence theory	[25][26]
Teacher and Student Competences	Awareness and Literacy	Prospective teachers' awareness of artificial intelligence	[29]
		Evaluation of artificial intelligence literacy education and content	[39]
		Course material effectiveness and "Education 4.0" applications	[37]
Creativity and Artificial Intelligence Integration	Artificial Intelligence in Art and Culture	Use of artificial intelligence in art and education	[38] [20]
		General education effects of artificial intelligence applications	[26]

When Table 3 is examined, it is seen that within the scope of Subtheme 1, Technological Applications and Approaches in Education, a wide range of studies have been carried out from analysing students' e-learning styles and strategies with web mining techniques to machine learning training for pre-service teachers in STEM field. In addition to pre-service teachers' attitudes towards teaching profession and artificial intelligence, the effects of artificial intelligence technologies on student achievement were also analysed. Sub-theme 2, Educational Evaluation Methods and Content Development, includes various evaluations ranging from teachers' views on the use of artificial intelligence to comparative analyses of national and international education programmes. Also, coding education and the educational effects of digital games are part of this theme. Sub-theme 3 focuses on Innovative Educational Strategies and Tools, evaluating the effectiveness of the use of AI-supported educational materials and chatbots in education. It also presents innovative approaches such as analysing e-learning environments based on the theory of multiple intelligences. Subtheme 4 focuses on Teacher and Student Competences and aims to determine the awareness of pre-service teachers about the concepts and applications of artificial intelligence, as well as to measure the effectiveness of educational content developed for students and the "Education 4.0" approach. Finally, Subtheme 5 explores the Integration of Creativity and Artificial

Intelligence and evaluates the use of artificial intelligence in art and education and the effects of these technologies on general educational practices and student attitudes.

The articles examined within the framework of the research questions were analysed under the theme of "aims" and divided into sub-themes, categories and codes. The categories and codes that emerged by analysing the purposes identified in the articles are summarised in Table 4 according to the relevant sub-themes.

Table 4 Aims of the articles

Sub Theme	Category	Code	Articles
Mental and Emotional Wellbeing	Life Skills Coaching	LifeSkills	[40]
Language Learning and Affective Fields	Effects on EFL Learners	EFLSensory	[41]
Communication Technologies in Education	Student-Teacher Communication	CommunicationTechnology	[45]
Social Interaction	Anti-Bullying Attitudes	Anti-Bullying	[48]
Cognitive Development	Science Education and Critical Thinking	Science Education	[42]
Reading Habits	Book Reading and Interaction	BookReading	[46]
Scientific Enquiry	Scientific Enquiry Skills	ScientificInquiry	[47]
Technology Acceptance	Teachers' Approach to Technology	TechnologyAcceptance	[49]
Extracurricular Learning Supports	Biology Learning Support	BiologySupport	[43]
Training Materials	Chatbot Usage and Learning Results	ChatbotTraining	[44]

When Table 4 is analysed, it is seen that under "Mental and Emotional Wellbeing", there is an article ([40]) addressing a chatbot-based coaching intervention to improve adolescents' life skills. Under "Language Learning and Affective Domains", there is an article ([41]) examining the effects of voice-based AI chatbots to improve Korean EFL learners' speaking competence and affective domains (interest, belief, motivation and perceived anxiety levels). Under "Communication Technologies in Education", there is an article ([45]) introducing a chatbot designed to facilitate communication between students and teachers. Under "Social Interaction", an article ([48]) investigating the use of chatbots in the fight against bullying and the effect of this technology on students' attitudes towards bullying is examined. Under "Cognitive Development", there is an article ([42]) evaluating the effectiveness of using cognitive style-based chatbots to develop science concepts and critical thinking skills. Under "Reading Habits", there is an article ([46]) that examines how the use of a chatbot as a "book chat buddy" affects students' interest and engagement in reading. Under "Scientific Inquiry", an article ([47]) examining the impact of an AI-supported chatbot on students' scientific inquiry skills is examined. Under "Technology Acceptance", there is an article ([49]) that investigates science teachers' attitudes towards AI technology, their level of acceptance and their intention to use this technology in teaching. Under "Extracurricular Learning Supports and Educational Materials", there is a study on a chatbot system that can support extracurricular biology learning ([43]) and another study examining the effect of chatbot use on student learning outcomes ([44]).

3.3. Which study groups were included in the studies and which research methodologies were used?

When the theses addressed within the framework of the research questions were analysed under the theme of "study groups", the data obtained are presented in Table 5.

Table 5 Theses and working groups

Theses	Working groups
[20]	Students studying in the departments of Mathematics, Turkish, Classroom and Preschool Teaching
[30]	Students of Science, Classroom, Preschool and Mathematics Teaching Departments
[27]	Teachers from different disciplines, including science teachers
[21]	Teacher candidate university students in the departments of computer and instructional technologies, science and mathematics teaching at the faculty of education

[22]	Studies investigating the effects of artificial intelligence technologies used in education on academic achievement between 2015-2021
[28]	Science teachers
[33]	8th grade students
[31]	6th grade students
[23]	Field experts, Information Technology and Software teachers and 6th grade students
[34]	Mother tongue teaching programmes of successful countries in PISA
[35]	Science teachers
[36]	Pre-service university students studying in undergraduate science teaching programme
[24]	6th grade students
[25]	5th grade students
[29]	Prospective teachers studying in any department of faculties of education, including science faculties
[38]	5th grade students
[39]	5th and 6th grade students, Teacher candidate university students, Teachers
[32]	6th grade students
[37]	8th grade students, Science and Physics Teachers
[26]	Studies on the use of artificial intelligence in education covering the period between 2000-2020

Among the thesis studies analyzed in Table 5, three theses ([23][37][39]) were identified that included both students and teachers as study groups. Six thesis studies ([24][25][31][32][33][38]) were identified for student groups only, in which the highest frequency was found with three different studies focusing on 6th grade students. While seven theses ([23][27][28][29][35][37][39]), five theses ([20][21][29][30][36]), and three theses ([22][26][34]) were found to use document analysis instead of direct study group. It was taken into consideration that some student groups were included in different combinations in the theses. While students at certain grade levels were analyzed independently in some theses, they were evaluated together with more than one grade level in others. In this context, when determining the number of studies on 5th grade students, not only the studies on this grade, but also the studies in which they were included together with 6th grade students were taken into account.

In the frequency analysis of thesis studies on teachers and students at various educational levels, 7 theses included teachers, 5 included pre-service teachers and 3 included document analysis; 5th and 6th grade students were the most frequently studied groups.

The data obtained when the articles addressed within the framework of the research questions were analysed under the theme of "study groups" are presented in Table 6.

Table 6 Articles and Working Groups

Articles	Working Groups
[40]	8th grade students
[41]	6th grade students
[45]	8th grade students and Science Teachers
[48]	5th grade students
[42]	8th grade students
[46]	5th grade students
[47]	5th and 6th grade students and Science Teachers
[49]	Science teachers
[43]	7th grade students
[44]	6th grade students

Among the articles analysed in Table 6, there was one article ([47]) in which 5th and 6th grade students and science teachers were included together and one article ([45]) in which 8th grade students and science teachers were included together. There is only one article (M8) consisting of teachers only. There are three articles including 5th grade students ([46][47][48]), three articles including 6th grade students ([41][44][47]), one study including 7th grade students ([43]) and three articles including 8th grade students ([40][42][45]). It was noted that some student groups were included in different combinations in the theses. While students at certain grade levels were analysed independently in some theses, in

others they were evaluated together with more than one grade level. In this context, for example, when determining the number of studies on 5th grade students, not only the studies on this grade, but also the studies in which they were included together with 6th grade students were taken into account. The graph in Figure 7 shows which groups were analysed more frequently in the studies.

According to the frequency analysis of the groups examined in the articles, 5th, 6th and 8th grade students were included in three articles each, while 7th grade students were examined in only one article; science teachers were included in three articles..

The theses addressed within the framework of the research questions were analysed under the theme of "method". The research methods used in thesis studies were divided into categories and codes and presented in Table 7.

Table 7 Methods used in theses

Category	Code	Theses
Quantitative Research Methods	Single group pretest-posttest design from experimental research models	[20]
	Artificial Neural Networks (ANN) method	[30]
	Screening model	[27]
	Meta-analysis method	[22]
	Relational survey model	[33]
	Quantitative approach	[36]
	Relational survey model	[29]
	Meta-analysis study	[26]
Qualitative Research Methods	Phenomenological study	[28]
	Document analysis method	[23]
	Qualitative study	[35]
	Analysed with qualitative and quantitative data using mixed research method	[38]
Mixed Research Methods	Mixed method design	[21]
	Explanatory sequential research design	[31]
	Convergent parallel mixed method design	[34]
	Embedded pattern	[24]
	Multi-stage mixed method design	[25]
	Design and development research	[39]
	Mixed research model	[32]
	Exploratory sequential description pattern	[37]

Table 7 shows that 20 thesis studies were conducted based on different research methods and were grouped under three methodological categories as "Quantitative Research Methods", "Qualitative Research Methods" and "Mixed Research Methods". In the quantitative methods category, the effects of artificial intelligence applications on student achievement and attitudes were analysed numerically in 8 studies. Among the models used were single group pretest-posttest design and Artificial Neural Networks. While 3 studies in the qualitative methods category looked in depth at the use of artificial intelligence technologies in education, phenomenology and document analysis methods were used. In the mixed methods category, 9 studies examined the effects of artificial intelligence in education with both quantitative and qualitative data; various designs such as mixed method design and explanatory sequential research design were preferred here.

In the thesis studies, 8 of the 20 theses were conducted with quantitative, 3 with qualitative and 9 with mixed methods; mixed methods were the most preferred research method.

The articles addressed within the framework of the research questions were analyzed under the theme of "method". The research methods used in the articles are divided into categories and codes and presented in Table 8.

Table 8 Methods used in articles

Category	Code	Theses
Quantitative Methods	Pre-Test-Post Test Experimental Design	[48][46]
	Experimental	[41]
	Quasi-Experimental	[42][43]
Qualitative Methods	Qualitative Data Collection	[40]
	Exploratory Case Study	[47]
Descriptive Methods	Descriptive Research	[49]
Mixed Methods	Mixed Methods Evaluation Research	[45]
	Interview and Documentation	[44]

The ten articles analyzed in Table 8 were conducted according to different research methods and were grouped under four main categories as "Quantitative Methods", "Qualitative Methods", "Descriptive Methods" and "Mixed Methods" depending on their methodological approaches. Under the "Quantitative Methods" category, there are two articles coded as "Pretest-Posttest Experimental Design" ([46][48]) and one article coded as "Experimental" ([41]), while two articles coded as "Quasi-Experimental" ([42][43]) complete this category. In the "Qualitative Methods" category, one article with the "Qualitative Data Collection" method ([40]) and one article with the "Exploratory Case Study" method ([47]) were classified. The only article ([49]) under "Descriptive Methods" was identified with the code "Descriptive Research". Finally, in the "Mixed Methods" category, there is one article with "Mixed Methods Evaluation Research" ([45]) and one article with "Interview and Documentation" ([44]).

In the article studies, 5 of the 10 articles were conducted with quantitative, 2 with qualitative, 1 with descriptive and 2 with mixed methods; the most preferred method was quantitative.

3.4. Which data collection tools were preferred in these studies and which data analysis methods were applied?

The theses addressed within the framework of the research questions were analysed under the theme of "data collection tools". The data collection tools used in thesis studies were divided into categories and codes and presented in Table 9 with their frequencies.

Table 9 Data collection tools used in theses

Category	Code	Theses	Frequencies
Quantitative data collection tools	Academic Achievement Tests	[21][31][32][37]	4
	Scales and Questionnaires	[20][30][36][25][29][32][26]	7
	Achievement Tests and Graded Scoring	[39]	1
	Online Course Participation Scale	[21]	1
	Field Experts Evaluations	[38]	1
Qualitative data collection tools	Semi-structured Interview Forms	[28][31][35][24][25][32]	6
	Teacher and Student Interview Forms	[23]	1
	Focus Group Interview Forms	[21][28][25]	3
	Researcher Diaries	[23][38]	2
	Audio/Visual Recordings	[38]	1
Both quantitative and qualitative data collection tools	Personal Information Forms	[30][27][21][28][25]	5
Other Original Data Collection Tools	Various Data Collection Tools (Interviews, Questionnaires, Diaries, etc.)	[23][24][38][39]	4
	Pictures Produced with GauGAN Programme	[38]	1
	Literature Review	[22][26]	2

Table 9 reveals the diversity of data collection tools among the 20 thesis studies. These were evaluated in four main categories: quantitative, qualitative, both quantitative and qualitative and original. Among quantitative tools, achievement tests and scales were used in 6 theses ([20][25][29][30][32][36]), while academic achievement tests were used in 4 theses ([21][31][32][37]) and various scales and questionnaires were used in 7 theses ([20][25][26][29][30][32][36]). Mastery tests and rubric scoring were

used in 1 thesis ([39]), online activities and participation scale in 1 thesis ([21]), field expert evaluations in 1 thesis ([38]) and participation scale in online courses in 1 thesis ([21]). Within the scope of qualitative tools, semi-structured interview forms were used in 6 theses ([24][25][28][31][32][35]) teacher and student interview forms in 1 thesis ([23]), focus group interviews in 3 theses ([21][25][28]), researcher diaries in 2 theses ([23][38]) and audio/verbal recordings in 1 thesis ([38]). Demographic data collection was categorised as both quantitative and qualitative in 4 theses ([21][25][27][28][30]) and mixed methods in 4 theses ([23][24][38][39]). Among the original data collection tools, pictures produced with GauGAN programme were evaluated in 1 thesis ([38]) and articles obtained from academic databases were evaluated in 2 theses ([22][26]).

Quantitative data collection tools were used 14 times, while qualitative tools were the most preferred method with 18 times; mixed methods were used only 4 times.

The articles addressed within the framework of the research questions were analyzed under the theme of "data collection tools". The data collection tools used in the articles are divided into categories and codes and presented in Table 10 with their frequencies.

Table 10 Data collection tools used in the articles

Category.	Code	Articles	Frequency
Quantitative Data Collection Tools	Surveys	[40][41][42][46][49][43]	6
	Scales and Tests	[48][42][43]	3
Qualitative Data Collection Tools	Interviews	[48][47][44]	3
	Observations (Records of researcher meetings, teacher's reflective notes)	[45][47]	2
Both Quantitative and Qualitative Data Collection Tools	Interviews, Anti-bullying attitude scale, Conversation diaries	[48]	1
	Interview, survey	[44]	1
Specific Data Collection Tools	Chatbot dialogs	[45][48][47]	3
	Feedback forms to evaluate student experiences	[43]	1
	Media and material verification forms	[44]	1

When the data collection tools in Table 10 are analyzed, it is seen that the use of questionnaires in six articles ([40][41][42][43][46][49]) stands out and has the highest frequency (6 times) among the quantitative data collection tools. Scales and tests were preferred in three articles ([42][43][48]) and both were used three times in total. Among qualitative data collection tools, interviews were used in three articles ([44][47][48]) and observation tools were used in two articles ([45][47]). In one article ([48]), which exhibited a complex data collection approach, interviews included both quantitative and qualitative data collection tools such as anti-bullying attitude scale and conversation diaries, representing the only example in this category. In terms of unique and specific data collection tools, chatbot dialogs were used in three articles ([45][47][48]). One article ([43]) used feedback forms to evaluate student experiences and one article ([44]) used media and material verification forms.

In the analyzed articles, quantitative tools were used 9 times with the highest frequency, while qualitative tools were used 5 times and specific tools were used 5 times.

The theses addressed within the framework of the research questions were analysed under the theme of "types of analysis". The types of analyses used in thesis studies are divided into categories and codes and presented in Table 11 with their frequencies.

Table 11 Types of analysis used in theses

Category	Code	Theses	Frequencies
General Statistical Tests and Analyses	T-Test, ANCOVA, ANFIS Analysis	[21][34][25]	3
	Dependent Sample t Test	[32]	1
	Mann-Whitney U Test, Wilcoxon Test	[31][37]	2
Descriptive and Content Analyses	Content Analysis, Descriptive Analysis	[31][35][24][25][38][32][37]	7

Factor Analysis and Reliability Tests	Exploratory and Confirmatory Factor Analysis, Cronbach's Alpha	[29]	1
Multiple Linear and General Linear Regression Analyses	Multiple Linear Regression Analysis	[33]	1
Other Statistical Methods	Using SPSS and SPSS Amos	[27]	1
	Hedges & Olkin's Effect Coefficient Calculation	[22]	1
	Descriptive Analysis and Case Study	[23][38]	2
Regression Models and Classification Algorithms	Various Data Mining Algorithms	[33]	1
	Deep Neural Networks (DSA)	[36]	1
Data Mining Usage	Data Mining Techniques	[20]	1
Thematic Analysis	Thematic Analysis	[28]	1
Content Analysis and Descriptive Analysis	Content Analysis and Descriptive Analysis Methods	[23][35][24][25][38][32]	6
Mixed Methods	Statistical and Qualitative Analyses	[21][24][25][38][39][32]	6
Multidimensional Analysis Approaches	SPSS, MAXQDA Usage and Mixed Methods	[39][32]	2

Table 11 shows the variety of data analysis types used in 20 theses. These analyses were examined under 11 main categories. Statistical analyses were generally preferred in 13 theses; t-test was used in one thesis ([21]) to evaluate the achievement difference between pre and post-test, while non-parametric tests such as Mann-Whitney U Test and Wilcoxon Test were used in two theses ([31][37]). Descriptive and content analyses were used in seven theses ([24][25][31][32][35][37][38]), and factor analysis and reliability tests were used in one thesis ([29]). Data mining and machine learning techniques were evaluated in two theses ([20][33]), and the performance of deep learning and data mining algorithms was evaluated in one thesis ([33]). Qualitative analysis methods were used in a total of eight theses ([23][24][25][28][32][35][37][38]), thematic analysis in one thesis ([28]) and content and descriptive analysis in seven theses ([23][24][25][32][35][37][38]). Mixed methods were preferred for combining quantitative and qualitative data in six theses ([21][24][25][32][38][39]).

In the analyzed theses, content and descriptive analysis methods were the most frequently used methods with 7 times; mixed methods with tools such as SPSS and MAXQDA were preferred 6 times.

The articles addressed within the framework of the research questions were analyzed under the theme of "types of analysis". The types of analysis used in the articles are divided into categories and codes and presented in Table 12.

Table 12 Types of analysis used in articles

Category.	Code	Articles	Frequencies
Statistical Analysis	Descriptive statistics, Paired sample t-tests	[41]	1
	Pair Sample T Test, Independent Sample T Test, Eta Square (Eta ²)	[42]	1
	ANOVA for repeated measures	[46]	1
	SPSS and AMOS statistical software, frequencies, percentages, arithmetic averages, standard deviations, Pearson simple correlation coefficients, t-tests, one-way ANOVA, path analysis	[49]	1
	Independent sample t-test, ANCOVA	[43]	1
Thematic and Content Analysis	Thematic analysis	[40]	1
	Analysis of dialogues	[45]	1
	Thematic Analysis, Speech Log Analysis	[48]	1
Mixed Analysis	ANCOVA (Statistical), Thematic Analysis (Qualitative)	[48]	1
	Quantitative and qualitative analysis techniques	[44]	1
Unspecified or General Analysis Approaches	A general analysis focusing on the use and various applications of AI chatbots in education (specific techniques not specified)	[47]	1

The types of analysis in Table 12 and the review of the related articles reveal the use of various research methodologies. In the Statistical Analysis category, descriptive statistics and paired sample t-tests were

used in article [41], while paired sample T Test, independent sample T Test and Eta Square analysis were used in article [42]. ANOVA analysis for repeated measures was discussed in article [46] and various statistical analyses such as frequencies, percentages, arithmetic averages, standard deviations, Pearson simple correlation coefficients, t-tests, one-way ANOVA and path analysis were performed in article M8 using SPSS and AMOS statistical software. Independent sample t-test and ANCOVA analysis were reported in article [43]. In the Thematic and Content Analysis category, thematic analysis was used in article [40], analysis of dialogues in article [45], and thematic analysis and conversation diary analysis in article [48]. The Mixed Analysis category presents the combination of ANCOVA (Statistical) and Thematic Analysis (Qualitative) in article [48], indicating that this article is included in both the Statistical Analysis and Thematic and Content Analysis categories. In the Unspecified or General Analysis Approaches category, a general analysis focusing on the use and various applications of AI chatbots in education was used in article [47] without specifying specific techniques. A study in which quantitative and qualitative analysis techniques are used together is included in article [44].

3.5. What are the results reached in these studies?

The theses addressed within the framework of the research questions were analysed under the theme of "results" and divided into three categories. The codes, theses and frequencies of these categories are shown in Table 13.

Table 13 Results obtained in theses

Category	Code	Theses	Frequency
Artificial Intelligence Technologies	Learning environments suitable for individual differences, preventing concept confusion, increasing participation in lessons, increasing motivation	[20][22][31][23][25][38][32][26]	8
Classification Models	Multilayer perceptron networks, suitability of deep neural networks	[30][36]	2
Measurement and Evaluation	Validity and reliability of the developed scale	[27]	1
Training Duration	Increasing the duration of training	[21]	1
Teacher Opinions	Suggestions and opinions on the use of artificial intelligence	[28]	1
Digital Games	Coding and digital games designed with coding	[31]	1
Metacognitive Behaviours	The effect of artificial intelligence teaching on metacognitive behaviours	[23]	1
Modelling Techniques	Artificial intelligence modelling techniques such as ANFIS	[34]	1
Artificial Intelligence Awareness	Prospective teachers' awareness of artificial intelligence	[29]	1
Chatbots	Potential contribution of chatbots to social studies education	[24]	1
Training Material	Effect of training material, concept test results	[37]	1

Thesis studies reveal that artificial intelligence technologies have positive effects on student achievement and attitudes. The most common benefits include creating learning environments suitable for individual differences, preventing concept confusion, increasing class participation and motivation. In addition, artificial intelligence classification models were found to be effective in assessing student achievement and identifying mental models. The theses also addressed issues such as teachers' suggestions and opinions on the use of artificial intelligence and the effect of digital games on student achievement.

The articles addressed within the framework of the research questions were analyzed under the theme of "results" and divided into three categories. The codes, articles and frequencies of these categories are shown in Table 14.

Table 14 Results obtained in the articles

Category.	Code	Articles
Effectiveness of Artificial Intelligence Applications in Education	Artificial intelligence chatbots are effective in improving students' speaking skills.	[41]
	The positive effect of using a cognitive style-based chatbot on improving students' science concepts and critical thinking skills.	[42]
	Artificial intelligence-supported chatbots can enrich students' reading experiences and increase their interest.	[46]
	The potential of artificial intelligence chatbots to guide students in scientific inquiry.	[47]
	Chatbot system has a positive effect on students' success in biology learning.	[43]
Student and Teacher Attitudes	Chatbot learning media is effective in improving student learning outcomes.	[44]
	Participants found the intervention useful and innovative and were positive that it could be supportive.	[40]
	Chatbot's potential to enhance teacher-student communication and help their expressive skills.	[45]
	Students' attitudes towards bullying changed positively after chatbot activities.	[48]
Artificial Intelligence and Learning Experiences	Science teachers positively accept the use of artificial intelligence in the classroom and are willing to integrate technology into their teaching processes.	[49]
	Artificial intelligence can contribute to student learning.	[49]
	Evaluation of chatbot learning media as an appropriate and effective learning tool for students.	[44]

The AI chatbots analyzed in the articles have been shown to be effective in improving students' speaking skills, critical thinking abilities and reading experiences. Chatbots also have the potential to improve student achievement in specialized areas such as scientific inquiry and biology learning. Studies on teacher and student attitudes have found positive results, such as chatbots enhancing classroom interaction and providing a positive outlook towards technology integration.

4. CONCLUSION AND RECOMMENDATIONS

This study analyzes how artificial intelligence and chatbot technologies are used in the context of secondary school science courses and makes a comparison between theses and articles in Turkish and foreign literature. The results of the study reveal that the use of AI technologies in education has positive effects on students' academic achievement and attitudes. These findings are in line with the benefits of technology integration in education, which are frequently emphasized in the literature, and support that it provides advantages such as providing learning environments suitable for individual differences, preventing concept confusion and increasing student motivation [24][42][43][44][47].

There are some fundamental differences between theses and articles, such as methodological approaches and research scope. Theses usually provide more comprehensive and detailed analyses, while articles address specific topics from a narrower perspective. However, both types of studies are similar in emphasizing the potential of AI and chatbots in education and their contribution to teaching processes. In particular, the aspects of chatbot technologies such as strengthening student-teacher interaction and increasing students' participation in scientific inquiry processes are common findings in both theses and articles and are consistent with similar studies in the literature [41][46][47].

In conclusion, this study shows that applications of AI and chatbot technologies in education have the potential to improve student achievement and motivation. These technologies can reshape teaching methods, enrich learning experiences and offer new assessment strategies for educators. The results of the research emphasize the need for further research on the more effective use of artificial intelligence and chatbots in education and point to new research avenues for more effective adoption and implementation of technological innovations in this field in education.

Considering the results, recommendations are given for each result:

Targeted professional development programs should be organized to increase the awareness of teachers and students on the use of educational technologies and chatbots.

To explore the potential of AI and chatbot technologies in education, course materials and learning activities that incorporate these tools should be developed.

The number of studies evaluating the effectiveness of chatbot use in education should be increased and the effects of these technologies on student achievement and attitudes should be examined in more depth.

A multidisciplinary approach should be adopted for the integration of artificial intelligence in education and the collaboration of experts from different disciplines such as educational sciences, computer science, linguistics and psychology should be encouraged.

During the development of chatbot and AI-based learning tools, the user experience should be optimized by actively soliciting feedback from students and teachers.

Long-term and comprehensive research should be conducted to evaluate the effects of AI-supported educational tools.

Education policy makers and school administrators should be encouraged to provide the necessary infrastructure and resources to support the use of AI and chatbots in education.

There is a need for qualitative studies examining teacher and student attitudes and usage scenarios on the use of artificial intelligence in education.

The social and ethical aspects of chatbot technology need to be addressed in detail, especially in the context of student privacy and data security.

The integration of artificial intelligence and chatbots into learning processes should be designed with students' individual learning needs and preferences in mind.

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