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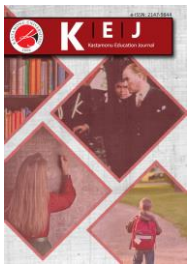

| Research Article / Araştırma Makalesi |

Developing a Curriculum Framework of Artificial Intelligence Teaching for Gifted Students

Özel Yetenekli Öğrenciler için Yapay Zekâ Çerçeve Öğretim Programının Geliştirilmesi [1]

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Keywords

1. Artificial Intelligence
2. BİLSEM
3. Gifted Students
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5. Special Ability

Anahtar Kelimeler

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Abstract

Purpose: The aim of this study is to determine the artificial intelligence (AI) subjects that can be handled at the beginner level for gifted students at the 6th grade -10th level studying in Science and Art Centers (BİLSEMs) and to prepare a framework curriculum for artificial intelligence to guide teachers.

Design/Methodology/Approach: This study was also considered as a design-based research; however, it was limited to needs analysis and design dimensions. In the needs analysis phase of this study, content analysis of existing curricula was used and in the design phase, quantitative analysis based on expert opinions was used. Within the scope of the needs analysis, 54 curricula structured at undergraduate and graduate levels of 41 different universities were examined. An AI subject list was created by examining the subjects included in AI curriculums. In the design phase, the AI subject list was presented to the expert opinion. Content validity criterion was used to determine whether each topic predicted by the experts "to be in the AI curriculum" was statistically significant. Hierarchical clustering analysis was also applied to the data set including the subject that the experts marked from the subject list. Based on the content validity rates (CVR) and hierarchical clustering analysis, the framework curriculum was created by determining the prominent topics.

Findings: According to the opinions of 20 experts in the research, it was seen that eight AI subjects were at the minimum CVR value and above. In the grouping made with cluster analysis, 13 subjects were obtained. Although there is a great deal of similarity between CVR and cluster analysis results, minor differences emerged between them. Based on both analyses, 6 learning domains and 22 sub-learning domains were determined regarding the subjects to be included in the curriculum.

Highlights: When compared to the studies on AI education in the literature, the prepared curriculum mostly overlaps with machine learning techniques and learning from data. There is a need to design, implement and evaluate the results of different activities aimed at the acquisitions of the curriculum put forward as a result of the study.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, Bilim ve Sanat Merkezlerinde (BİLSEM) öğrenim görmekte olan altıncı - 10. sınıf düzeyindeki özel yetenekli öğrenciler için başlangıç düzeyinde ele alınabilecek yapay zeka (YZ) konularının belirlenmesi ve öğretmenlere yol gösterici bir YZ çerçeve öğretim programının hazırlanmasıdır.

Materyal ve Yöntem: Bu çalışma tasarım tabanlı araştırma olarak ele alınmış ancak ihtiyaç analizi ve tasarım boyutu ile sınırlandırılmıştır. İhtiyaç analizi aşamasında mevcut öğretim programlarının içerik çözümlemesine ve tasarım aşamasında ise uzman görüşlerine dayalı nicel çözümlemelere başvurulmuştur. İhtiyaç analizi kapsamında 41 farklı üniversitenin lisans ve lisansüstü düzeyde yapılandırılmış 54 adet öğretim programı incelenmiştir. Yapay zeka öğretim programlarında yer alan konular incelenerek bir yapay zeka konu listesi oluşturulmuştur. Tasarım aşamasında oluşturulan yapay zeka konu listesi uzman görüşüne sunulmuştur. Uzmanlar tarafından "YZ öğretim programında olması" öngörülen her bir konunun istatistiksel olarak anlamlı olup olmadığını belirlemek için kapsam geçerlik ölçütü kullanılmıştır. Uzmanların konu listesinden işaretledikleri konuların yer aldığı veri kümesine ek olarak hiyerarşik kümeleme analizi de uygulanmıştır. Kapsam geçerlik oranları (KGO) ve hiyerarşik kümeleme analizine dayalı olarak ön plana çıkan konular belirlenerek çerçeve öğretim programı oluşturulmuştur.

Bulgular: Araştırmada 20 uzman görüşüne göre KGO minimum değer ve üzerinde sekiz yapay zeka konusunun yer aldığı görülmüştür. Kümeleme analizi ile yapılan gruplamada ise 13 adet konu elde edilmiştir. KGO ile kümeleme analizi sonuçları arasında büyük ölçüde benzerlik olmakla beraber aralarında küçük farklılıklar ortaya çıkmıştır. Her iki analize dayalı olarak öğretim programında yer alacak konular ve konulara ilişkin 6 öğrenme alanı ve 22 alt öğrenme alanı belirlenmiştir.

Önemli Vurgular: Alanyazında yapay zeka eğitimi ile ilgili yapılan çalışmalar ile karşılaştırıldığında ortaya konan öğretim programı en çok makine öğrenmesi teknikleri ve veriden öğrenme konuları ile örtüşmektedir. Çalışma sonucunda ortaya konan öğretim programındaki kazanımlara yönelik farklı etkinliklerin tasarlanmasına, uygulanmasına ve sonuçlarının değerlendirilmesine ihtiyaç duyulmaktadır.

[1] This study is a part of PhD dissertation prepared by the first author under the supervision of the second author.

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INTRODUCTION

The rapid development in digitalization has revealed the concept of big data by increasing the amount of data held in digital environments. Artificial intelligence (AI) has come to the fore with the increase in knowledge in keeping, processing and analyzing data in digital environments. AI studies are increasing day by day and are trying to solve problems in many areas. In recent years, the importance of educating individuals with these skills for the development of AI technologies has increased.

AI education is provided at different education levels. In recent years, AI has also started to come to the agenda for students studying at K12 (primary and secondary education) level (AI4K12, 2018; Long & Magerko, 2020; UNESCO, 2022). In particular, on AI education for the K12 level; the Association for the Advancement of Artificial Intelligence (AAAI) and The AI for K12 (AI4K12) Community, supported by the Computer Science Teachers Association (CSTA), are working on skill sets and/or curriculum for AI at the K12 level. Similarly, Long & Magerko (2020) present a conceptual framework about what competencies should be in AI literacy. In another study, Lao (2020) offers a training framework for machine learning (ML). On the basis of these studies, it offers some competency framework for K12 in AI education. Although such studies have created various skill sets and frameworks on AI education, a concrete curriculum has not yet been put forward on the subject.

While some countries in the world have started to include artificial intelligence curriculum at the K12 level, some countries are conducting studies on this matter (UNESCO, 2022). Although there are some initiatives at the K12 level in the country where this study was conducted (Türkiye), there is a need for more studies on this matter. In the framework curriculum prepared for the field of information technologies within the Ministry of National Education (MEB), Vocational and Technical Anatolian High School, there is an optional "AI and ML" course for 11th and 12th grades (MEB, 2022a). In addition, the Board of Education has included "AI applications" as an elective course for the seventh grade and eighth grades of secondary school in its latest update of the Weekly Course Schedule for Primary Education Institutions (MEB, 2023). Apart from this, it is seen that there are efforts of some private or public education institutions on AI teaching. At the forefront of these efforts is the Science and Art Centers (BİLSEM), where gifted students are educated in Türkiye.

Gifted students need differentiated instruction beyond the curriculum in their schools (Marland, 1972; Sak, 2011). Science and Art Centers have been established in Türkiye in order to provide differentiated education for gifted students at the K12 level. Apart from the formal education institutions they attend, these students have an activity-based learning experience in these centers. For the teaching of AI in BİLSEMs, the AI Module has been included in the Information Technologies and Software field for the ÖYG (Special Talent Development Program) program by the Ministry of National Education, General Directorate of Special Education and Guidance. There are many AI subjects in this module (MEB, 2022b). According to the BİLSEM directive, the ÖYG program is planned and implemented for two academic years for students diagnosed in the field of general mental ability (MEB, 2022c). In this sense, it is seen that there is a need for an initial framework curriculum for students who will just start their AI studies in BİLSEMs.

The fact that AI, whose importance is increasing day by day, is not sufficiently included in the curriculum of formal education institutions at the K12 level in Türkiye, emerges as a need for gifted students who have an interest and ability in this subject. BİLSEMs have an important purpose for gifted students who need differentiated education in Türkiye. With their aims and opportunities, BİLSEMs are important educational institutions for students who are interested in AI and have special abilities. The fact that AI has a wide field of study and makes use of different disciplines reveals the need for guiding studies for teachers in teaching AI at the K12 level. The aim of this study is to determine the AI subjects that can be handled at the beginner level for gifted students at the sixth grade -10th grade level who are being taught in BİLSEMs and to prepare a framework curriculum to guide teachers.

What is AI?

McCarthy (2007) defines AI as "*the science and engineering of making intelligent machines, especially intelligent computer programs*" and divides it into 12 sub-branches. These are logic AI, search, pattern recognition, representation, inference, common sense knowledge and reasoning, learning from experience, planning, epistemology, ontology, heuristics and genetic programming (McCarthy, 2007). Antebi (2021), shows AI and its sub-fields as in Figure 1.

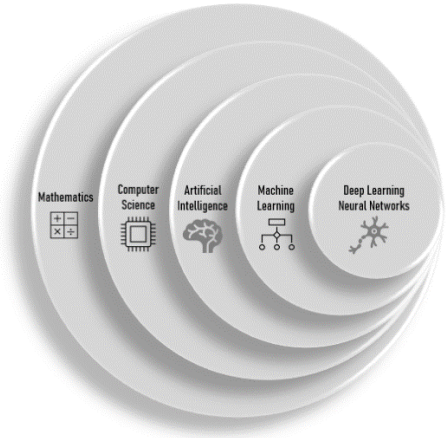

Figure 1. AI and its sub-fields (Antebi, 2021).

As seen in Figure 1, AI is based on mathematics and computer science. In addition, ML, deep learning and neural networks appear to be sub-work areas of AI. Machine learning, a sub-study of artificial intelligence, is "*programming computers to optimize a performance measure using sample data or past experiences*" (Alpaydın, 2004). Another issue to be emphasized is that AI is an umbrella concept and it consists of many sub-studies such as ML, expert systems, speech recognition, image processing, natural language processing, robotics and so on. ML and expert systems include decision-making processes based on the processing of data, while others include dominant features such as perception and/or reaction. Of these, ML and expert systems include decision-making processes based on the processing of data, while others include dominant features such as perception and/or reaction.

AI Curriculum Studies

With the rapid development in technology, AI studies in the world have gained even more speed and AI education has come to the forefront at the K12 level after graduate and undergraduate levels. Some countries have taken action on this issue and have started AI curriculum studies at the K12 level. United Nations Educational, Scientific and Cultural Organization (UNESCO), which is conducting a study on mapping AI curriculum endorsed by governments, has prepared a comprehensive report on this matter (UNESCO, 2022). It is stated in the report that UNESCO has contacted 193 member states through official correspondence channels and received responses from a total of 51 countries. AI curricula for K12 endorsed and implemented by governments are given in Table 1 (UNESCO, 2022).

Table 1. K-12 AI curriculum endorsed and implemented by governments (UNESCO, 2022)

Countiries	Curriculum Title	Curriculum Developer	Educational Levels		
			Primary school	Middle school	High school
Armenia	Curriculum of ICT	Government		X	X
Austria	Data Science and Artificial İntelligence	The Federal Ministry of Education, Science and Research			X
Belgium	IT Repository	Fédération Wallonie-Bruxelles (French-speaking Community of Belgium)			X
China	AI curriculum embedded in the Information Science and Technology curriculum	The Ministry of Education of the People's Republic of China	X	X	X
India	Atal Tinker Labs artificial intelligence modules	Atal Tinker Labs, Atal Innovation Mission, NITI Aayoag		X	X
Republic of Korea	'AI Mathematics' under the Mathematics Subject Group for high schools	Korean Foundation for the Advancement of Science and Creativity			X
	'AI Basics' under Technology Home Economics Subject Group for high schools	Korean Foundation for the Advancement of Science and Creativity			X
Kuwait	Standard curriculum	Curriculum technical guidance experts and teachers	X	X	
Portugal	Information and Communication Technologies	Stade school teachers of ICT and Mathematics	X	X	X

Countiries	Curriculum Title	Curriculum Developer	Educational Levels		
			Primary school	Middle school	High school
Qatar	Computing and Information Technology	Binary Logic, Ministry of Education and Higher Education	X	X	X
	Computing and Information Technology (High-Tech Track)	Binary Logic, Ministry of Education and Higher Education			X
Serbia	Informatics and programming – Grade 8	Ministry of Education working group		X	
	Modern technologies in gymnasiums – Grade 3 and 4	Ministry of Education working group			X
The United Arab Emirates	AI curriculum embedded under the Technology Subject Framework	Ministry of Education	X	X	X

As presented in Table 1, there are 14 AI curriculum at the K12 level, endorsed by the government and implemented in 11 countries. It is seen that %71,4 (10) curriculum are under the heading of information technologies/information and communication technologies/technology. It is seen that %71,4 (10) curriculum were developed by the Ministries of National Education or state institutions, and %28,6 (four) of them were developed by foundations or communities. It is seen that six of the 14 curriculum developed are high school, four of them are primary school-middle school-high school, two of them are middle school-high school, one of them are primary-middle school and one of them is middle school. Table 2 shows the AI curriculum at the K12 level that governments continue to develop (UNESCO, 2022).

Table 2. AI curriculum that continue to be developed by the official institutions of the countries (UNESCO, 2022)

Countries	Curriculum Title	Curriculum Developer	Educational Levels		
			Primary School	Middle School	High School
Germany	Identifying and Formulating Algorithms	Standing Conference of the Ministers of Education and Cultural Affairs of the Länder	X	X	X
Jordan	Digital skills	National Center for Curriculum Development		X	X
Bulgaria	Computer Modeling, Information Technology And Informatics	Expert groups (academia, teachers, education experts)	X	X	X
Saudi Arabia	Digital skills	Binary Logic and Tatweer Co.	X	X	X
Serbia	Technique and Technology	Ministry of Education working group		X	
	AI in gymnasium	Ministry of Education working group			X
	AI in all high schools	Ministry of Education working group			X

As presented in Table 2, the process of developing seven AI curriculum at K12 level by governments in five countries continues. It is seen that five of these seven curriculum are under the heading of algorithm/digital skills/information technology. It is seen that the majority of these seven curriculum were developed by the Ministries of National Education or state institutions. It is seen that three of the seven curriculum that are in development process are primary school-middle school-high school, two are high school, one is middle school-high school and one is middle school.

In Türkiye, there is an optional "AI and ML" course for 11th and 12th grades in the field of information technologies within the Vocational and Technical Anatolian High School at the K12 level (MEB, 2022a). The Board of Education has included "AI applications" as an elective course for the seventh grade and eighth grades of secondary school in its latest update of the Weekly Course Schedule for Primary Education Institutions (MEB, 2023).In addition, there are private initiatives of some institutions for AI education at the K12 level in Türkiye. In Türkiye, AI studies are carried out according to the interests and abilities of the students in the Science and Art Centers, where gifted students at the K12 level are educated. In addition, the “Deneyap Technology Workshops”, which were realized in cooperation with the Ministry of Industry and Technology, Ministry of Youth and Sports, The Scientific And Technological Research Council of Türkiye (TÜBİTAK) and the Turkish Technology Team Foundation in Türkiye and are aimed to be established in 81 provinces, allow students at the K12 level to conduct AI studies (https://www.deneyapturkiyeorg/). The first National Artificial Intelligence Strategy (NAIS) (2021-2025) which also includes targets for such AI education studies was published in Türkiye. NAIS (2021-2025), which was prepared in line with the eleventh development plan and presidential annual programs and is the first national strategy document of our country in the field of AI, entered into force after being published in the Official Newspaper dated 20.08.2021 and numbered 31574 (Republic of Türkiye Official Newspaper, 2021). One of the objectives included in the strategy document prepared in cooperation with Presidency of the Republic of Türkiye Digital Transformation Office and the Ministry of Industry and Technology has been determined as "to enable pre-higher youth to receive applied training in algorithmic thinking, coding and AI in line with their interests, abilities and temperaments, in accordance with their education level". One of the measures to be taken for this purpose is expressed as "the

development of training models that will provide experimentation, interaction and deepening in the field of AI and programs according to existing and/or new structures will be encouraged" (NAIS, 2021). In the national AI strategy, it is an important step to set the aim of ensuring that young people receive AI education before higher education and to encourage the development of education models in this regard as a precaution. This study is also important in terms of serving the purposes of NAIS (2021-2025).

AI Education

There are important studies that present conceptual frameworks on AI education and competencies for students. Some studies on AI education are given below. “The AI for K-12 (AI4K12)” Initiative, supported by the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) revealed the “Five Big Ideas in Artificial Intelligence” study in Figure 2, which includes some competencies for students in each grade group at the K12 level (AI4K12, 2018).

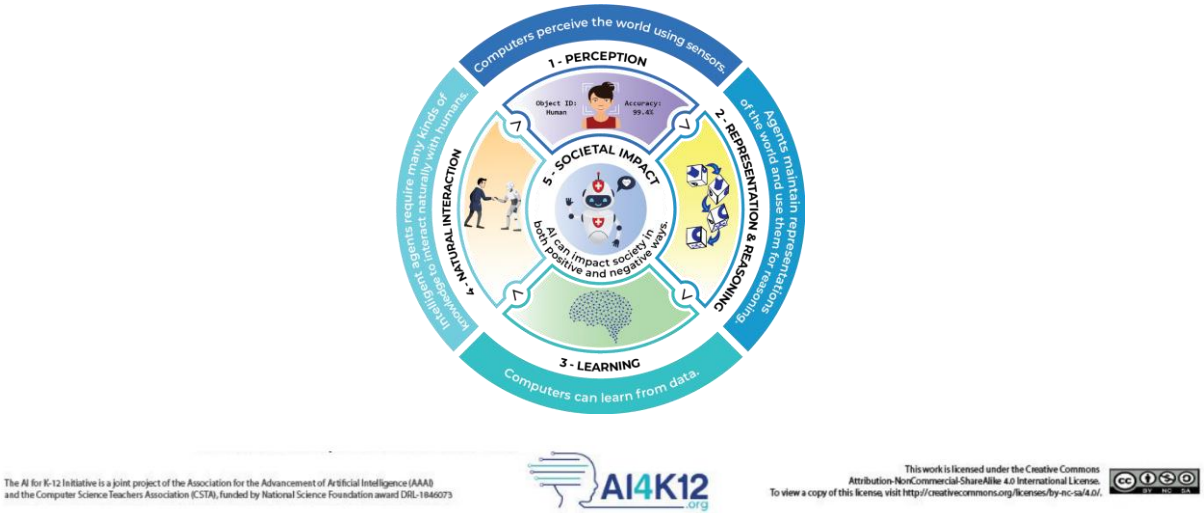

Figure 2. Five big ideas in AI (AI4K12, 2018)

These five big ideas in Figure 2 are explained as follows (Touretzky, Gardner-McCune, Martin & Seehorn, 2019);

1. Computers perceive the world using sensors: perception is the process of obtaining information from sensory signals. The ability of computers to "see" and "hear" well enough to be useful in practice is one of AI's greatest achievements. Students should understand that machine perception of spoken language or visual images requires extensive domain knowledge.

2. Agents maintain models/representations of the world and use them for reasoning: AI systems are often described as intelligent agents that perceive and represent the world, think and produce outputs that affect the world. Students should understand that computers create representations using data and that these representations can be manipulated by applying reasoning algorithms that derive new information from what is already known.

3. Computers can learn from data: ML algorithms allow computers to construct their own representations using training data provided by humans or acquired by the machine itself. Students should understand that ML is a type of statistical inference that finds structures in data.

4. Enabling agents to interact comfortably with humans is a major challenge for AI developers: understanding humans is one of the most difficult challenges intelligent agents face. This includes tasks such as speaking in natural language, recognizing emotional states, and inferring intentions from observed behavior. Students should understand that while computers have a limited understanding of natural language, they currently lack the general reasoning and speaking abilities of even a child.

5. AI applications can impact society in both positive and negative ways: students should be able to identify ways that AI contributes to their lives.

In another study, Lao (2020) presents an ML education framework based on self-regulation, constructivism and computational thinking. Lao (2020) presents a ML education framework based on self-efficacy, constructivism and computational training theories for people who like to repair/experiment or who are in a consumer position (Figure 3).

Figure 3. ML education framework (Lao, 2020)

The ML education framework in Figure 3 consists of three interrelated categories. These are knowledge, skills and attitudes. The knowledge category includes general information about ML, information about the methods used in ML, the subject of bias in ML systems, and information about the social effects of ML. The skills category includes which problems can be solved with ML, planning a solution for a given problem in ML, creating various ML artifacts, analyzing ML design goals and results. Also, this category includes ML advocacy and independent out-of-class learning, which refers to students' ability to interact critically with ML in their community. Attitudes category includes students' interest in ML, students' feeling of belonging to a ML community, students' feeling powerful about ML, and students' persistence in ML (Lao, 2020).

In one another study, Long & Magerko (2020), based on current research, provides a general framework on what competencies are required for AI literacy and what kind of design features should be taken into account. Based on the literature review, the study includes a conceptual framework consisting of five different overarching themes with questions about AI and a set of competencies for each theme (Table 3).

Table 3. AI literacy conceptual framework and competencies (Long & Magerko ,2020)

Theme	Competency
What is AI?	1-Recognizing AI 2- Understanding Intelligence 3- Interdisciplinarity 4- General vs. Narrow
What can AI do?	5-Strengths and Weaknesses of Artificial Intelligence 6-Imagine Future Artificial Intelligence
How does AI work?	7-Representations 8-Decision - Making 9- Machine Learning Steps 10-Human Role in Artificial Intelligence 11-Data Literacy 12-Learning from Data 13- Critically interpreting Data 14- Action and Reaction 15- Sensors
How should AI be used?	16-Ethics
How do people perceive AI?	17- Programmability

As seen in Table 3, there are 17 separate competencies in the conceptual framework consisting of five themes. A significant number of these competencies (nine competencies) are related to how AI works. As another purpose of their study, the researchers put forward a definition of AI literacy based on existing research. This definition is as follows : "*AI literacy as a set of competencies that enables individuals to critically evaluate AI technologies; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace*" (Long & Magerko, 2020).

The studies mentioned above provide important frameworks for AI education and present some competencies that students are expected to have. Knowing to what extent the countries that are implementing or in the process of developing AI curriculum include these competencies is important in terms of guiding AI curriculum development studies. UNESCO, which has conducted a comprehensive study on this matter, has mapped the K12 AI curriculum endorsed by governments (UNESCO, 2022). In the study, information was collected from member states and private sector actors through surveys. In this mapping study, the AI curriculum content was divided into nine subject areas under three categories (Table 4) and the respondents were asked to provide information about the time and percentage they allocate to these subject areas in their curriculum.

Table 4. AI curriculum areas (UNESCO, 2022)

Category	Topic area	Competency and curriculum considerations
AI foundations	Algorithms and programming	*"Together with data literacy, algorithms and programming can be viewed as the basis of technical engagement with AI".*
	Data literacy	*"A majority of AI applications run on 'big data'. Managing the data cycle from collection to cleaning, labelling, analysis and reporting forms one of the foundations for technical engagement with using and/or developing AI. An understanding of data and its functions can also help students understand the causes of some of the ethical and logistical challenges with AI and its role in society".*
	Contextual problem-solving	*"AI is often framed as a potential solution to business-related or social challenges. Engaging at this level requires a framework for problem-solving in context, encompassing things like design thinking and project-based learning".*
Ethics and social impact	The ethics of AI	*"Regardless of technical expertise, students in future societies will engage with AI in their personal and professional lives – many do so from a young age already. It will be important for every citizen to understand the ethical challenges of AI; what is meant by 'ethical AI'; concepts such as transparent, auditable, and fair use of AI; and the avenues for redress in case of unethical or illegal use of AI, e.g. that which contains harmful bias or violates privacy rights".*
	The social or societal implications of AI	*"The social impacts of AI range from requiring adjustments to legal frameworks for liability, to inspiring transformations of the workforce. Survey respondents were asked about the extent to which their curricula targeted these issues. Trends such as workforce displacement, changes to legal frameworks, and the creation of new governance mechanisms were given as examples".*
	Applications of AI to domains other than ICT	*"AI has a wide range of applications outside of computer science. The survey asked participants whether and to what extent AI applications in other domains were considered. Art, music, social studies, science and health were given as examples".*
Understanding, using and developing AI	Understanding and using AI techniques	*"This area included (1) the extent to which theoretical understandings of AI processes were developed (e.g. defining or demonstrating patterns, or labelling parts of a machine learning model); and (2) the extent to which students used existing AI algorithms to produce outputs (e.g. training a classifier). Machine learning in general, supervised and unsupervised learning, reinforcement learning, deep learning, and neural networks were given as examples of AI techniques".*
	Understanding and using AI technologies	*"AI technologies are often human-facing applications which may be offered 'as a service'. NLP and computer vision were given as examples. Respondents were asked about the extent to which learners used existing AI technologies to complete tasks or projects, and/ or studied the processes of creating these Technologies".*
	Developing AI technologies	*"Developing AI technologies deals with the creation of new AI applications that may address a social challenge or provide a new type of service. It is a specialized field requiring knowledge of a range of complex techniques and skills in coding, mathematics (especially statistics), and data science".*

UNESCO (2022) has revealed the rates of inclusion of the categories in Table 4 in the curriculum, based on the information received from the participants. "AI foundations", which forms the basis of many curriculum, constitutes an average of 41% of the curriculum time. Another category, "Ethics and social impact", accounts for an average of 24% of the hours. "Understanding, using and developing AI" accounts for an average of 25% of the hours. Since not all countries responded to requests for clarification, 10% are shown as "unspecified" (Figure 4).

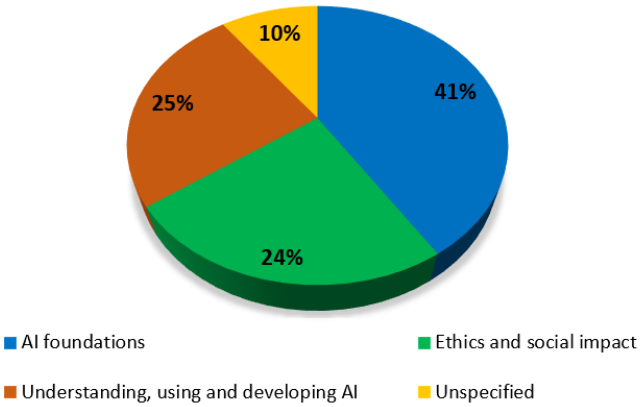

Figure 4. The rates of inclusion of AI Curriculum Categories (UNESCO, 2022)

According to the information received from the participants, the average durations committed for the subject domains are given in Table 5. (UNESCO, 2022).

Table 5. The average hour commitment (all) of AI subject domains (UNESCO, 2022)

AI foundations	99.8
Ethics and social impact	29.7
Understanding, using and developing AI	39.0

As seen in Table 5, while “AI foundations” has the most time (99.8), it is followed by “Understanding, using and developing AI” (39.0) and “Ethics and social impact” (29.7). In its report, UNESCO (2022) also mentions the extent to which AI main domains are included in different curriculum in terms of time. It is appeared that “AI foundations” is included in the curriculum at different rates between 0% and 75%, “Ethics and social impact” is between 0% and 60%, and “Understanding, using and developing AI” varies between 0% and 70%. The report also states that different curriculum focus on different domains. For instance; Armenia allocates 70% of the time to the domain of "Understanding, using and developing AI" in the Curriculum of ICT, while 0% of the time is allocated to the domains of "Ethics and social impact" and "AI foundations". In the "Computer Modeling, Information Technology and Informatics" Curriculum, Bulgaria allocates 75% of the time to the "AI foundations" domain, 0% to the "Understanding, using and developing AI" and 15% to the "Ethics and social impact" domain. In the Informatics and Programming curriculum, Serbia allocates 20% of the time to the field of "AI foundations", 20% to the domain of "Understanding, using and developing AI", and 60% to the domain of "Ethics and social impact". The report also includes the curriculum numbers, hour intervals and average time commitments covering the sub-domains given in Table 4. This information is given in Table 6 (UNESCO, 2022).

Table 6. Engagement of AI sub-subjects domains in the curriculum (UNESCO, 2022)

Category	Topic area	Number covering the topic area (n = 21)	Range of hours	Average hour commitment (all)
AI foundations	Algorithms and programming	19	0-269	50.0
	Data literacy	17	0-78	21.5
	Contextual problem-solving	14	0-198	28.3
Ethics and social impact	The ethics of AI	17	0-54	10.8
	The social or societal implications of AI	12	0-78	8.1
	Applications of AI to domains other than ICT	18	0-92	11.9
Understanding, using and developing AI	Understanding and using AI techniques	18	0-128	14.6
	Understanding and using AI technologies	12	0-307.5	21.1
	Developing AI technologies	6	0-30	3.3

It is seen in Table 6 that the subject domain covered by the "Algorithms and programming" domain in the AI foundations category and the average hours allocated are more than the domains of "Data literacy" and "Contextual problem-solving". It also seems that the time interval is longer than the other two areas. While "Data literacy" ranks second as the subject domain covered

by the field, "Contextual problem-solving" field ranks second in terms of average time and hour range. In the While in the "Ethics and social impact" category, "Applications of AI to domains other than ICT" ranks first in terms of subject domain coverage, "The ethics of AI" ranks second with a value close to it. It is seen that these two domains are close to each other in terms of committed time, and "The social or societal implications of AI" is allocated less time than the other two fields. It is seen that the "Applications of AI to domains other than ICT" domain has the widest time range. In the “Understanding, using and developing AI” category, the domain of “Understanding and using AI techniques” ranks first in terms of subject domain coverage, followed by “Understanding and using AI Technologies” and “Developing AI Technologies”. It is noteworthy that the “Understanding and using AI Technologies” domainhas a longer time range than the other two domains. The "Understanding and Using AI Technologies" domain comes first in terms of allocated hours.

When the evaluations made on the basis of the curriculum are examined, the curriculum prepared in Qatar includes a compulsory course for all grade levels and an elective 'high technology' course for high schools. Both sections include AI learning outcomes related to algorithms, programming, ethics and social impact, and understanding and using AI tools and technologies. Students in high-tech fields are also noted to be involved in the development of AI technologies. It is underlined that the purpose of the curriculum is to follow current trends in information technologies and to review it periodically. It is stated that another important issue is to ensure that the curriculum is not dependent on specific technologies, platforms or applications, and to guarantee the sustainability of the standards over time (UNESCO, 2022).

In another study on the comparison of artificial intelligence curricula, Li (2020) compared curricula in Canada, India, the US and the UK. He states that the four curricula he compared converge and diverge in terms of basic elements. He states that the Canadian and Indian curricula emphasize technical subjects, while the US curriculum emphasizes social and ethical issues. It underlines that the UK curriculum covers the widest and most balanced range of subjects.

Williams, Kaputsos & Breazeal (2021) share some evaluations after the implementation of the curriculum they developed. They developed the AI and Ethics Curriculum for secondary school teachers as an introduction to AI. The study includes the training of teachers for a five days AI course and teacher feedback regarding the process. It is stated that the curriculum prepared in the study includes the third idea of the five big ideas put forward by AI4K12 (2018), that “computers can learn from data”, and the fifth idea, that “AI applications can impact society in both positive and negative ways”. Additionally, It is indicated that the competencies numbered one and two "Recognizing AI" and "Understanding Intelligence" are included in the framework put forward by Long and Magerko (2020) and the skills numbered two and three "ML project planning" and "creating ML artifacts" are included in the framework put forward by Lao (2020). As a result of the study, researchers point out how old computers and other devices can be used in practice and the difficulties experienced in accessing such devices, especially in rural areas. Similarly, the problems experienced in internet access and the cost of robots are mentioned. For future research, the importance of students' cultural backgrounds and designing AI platforms together with teachers to support their learning needs is emphasized.

In its evaluation of the curriculum in practice in the UNESCO (2022) report, it is stated that the AI curriculum should be coordinated with the mathematics curriculum and classroom requirements. It is marked that curriculum should also address a wide range of contexts and the different opportunities and challenges of both urban and rural environments. The conclusion of the report includes nine key findings and 13 recommendations. Some of the highlights of these findings and recommendations are as follows: it is stated that there are a limited number of AI curriculum developed and implemented by governments, and there are very few published studies on the evaluation of curriculum. It is underlined that more pilot studies should be conducted to obtain feedback and that evaluations regarding the impact on students should be evidence-based. It is stated that discussion on ethics alone, without sufficient knowledge about AI techniques and tools, will not be sufficient to guide students to an in-depth understanding. It is emphasized that the AI curriculum should not be associated with specific technologies, brands or platforms, and that students should gain basic knowledge to apply AI in different domains and contexts.

Educational Platforms for AI

With the emergence of AI at the K12 level, some software companies have developed some applications for students to work with AI (Table 7.)

Table 7. AI applications for K12

Application Name	Web address
Machine Learning for Kids	https://machinelearningforkids.co.uk/
mBlock	https://www.mblock.cc/
PictoBlox	https://pictoblox.ai/

Machine Learning for Kids, shown in Table 7, is a platform where students can make different applications by entering the specified web page. In Machine Learning for Kids, students can work on classifying text, numbers, pictures or sounds. The mBlock and pictoblox in Table 7 are the platforms where students can make various applications through the software they downloaded to their computers from the specified web page. In mBlock, students can work on classifying objects, detecting mood, detecting age, and detecting some situations related to physical appearance by using the camera. Similarly, in the pictoblox application, which is another application, students can make use of the camera to work on detecting moods or detecting some situations related to physical appearance.

Such applications can be beneficial in terms of drawing the attention of young children to AI, showing what AI can do and making some projects. However, the ready and limited features offered by such applications are insufficient for students who plan to advance in AI.

It is seen that most of these initiatives at the K12 level are tool/software based and are independent of the mathematical and statistical infrastructure of the algorithms used. AI systems express the data they receive from outside numerically and obtain an output by reaching the result with the mathematical and statistical calculations they make over the numbers. Therefore, it is important to emphasize the teaching of algorithms based on statistical and mathematical theories instead of a teaching approach based on tool-based activities unaware of these algorithms, in terms of understanding what kind of system works in the background of AI.

The Basic Approach Followed in the Study

In this study, it is planned to focus mainly on the mathematical and statistical dimensions of AI for sixth grade - 10th grade gifted students who have not received artificial intelligence education before, but also include basic concepts and ethical dimensions. Students are not required to know any programming language. The main purpose is to ensure that students learn AI algorithms and techniques, make applications using simple tools and relate them to daily life. The dimensions focused on in the study are given in figure 5.

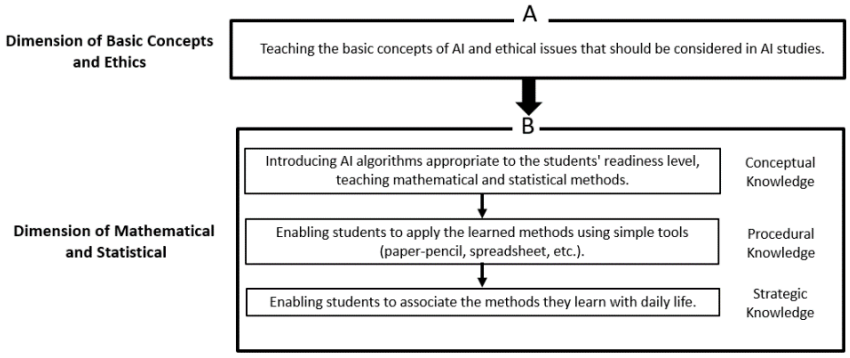

Figure 5. Dimensions focused on in the study

As seen in Figure 5, the mathematical and statistical dimension, which is mainly focused on in the study, consists of three stages. These are introducing AI algorithms, teaching mathematical and statistical methods (conceptual knowledge), applying the learned methods using simple tools (procedural knowledge), and associating the learned methods with daily life (strategic knowledge).

It is seen that different types of information are included in the literature. Conceptual knowledge is "*static knowledge about facts, concepts, and principles valid in a particular field. Conceptual knowledge functions as additional information that problem solvers add to the problem and use to realize the solution*" (De Jong & Ferguson-Hessler, 1996). Procedural knowledge is "*about knowing how. In other words, procedural knowledge refers to the skills, processes, and algorithms associated with a topic or content area. Usually represented as a series of steps, procedural knowledge requires students to know when to apply certain skills, processes, and algorithms*" (Almarode, Fisher & Frey, 2021). Strategic knowledge is "*the knowledge of general strategies for learning, thinking and problem solving*" (Anderson et al., 2001). In other words, it is "*knowing why and when to use declarative and procedural knowledge and when to leave declarative and procedural knowledge while engaged in new learning*" (Almarode, Fisher & Frey, 2021).

Aim of the Research

One of the goals of the 2023 Education Vision document published by the Ministry of National Education is to develop learning environments, course structures and materials for gifted students (MEB, 2018a). In this vision document, one of the objectives planned for this purpose is "curriculum studies covering formal and non-formal education for the education of gifted individuals

will be initiated". In BİLSEMs, where gifted students are educated in Türkiye, education and training activities are carried out outside the hours of formal education. The aim of BİLSEMs is to enable students to gain creative thinking, discovery, invention, success in social relations, innovation, leadership, communication and artistic skills. In addition, in BİLSEMs, it is aimed that students gain the discipline of scientific study in line with their special abilities, think interdisciplinary, solve problems, and realize projects to meet the determined needs (MEB, 2022c). In this context, it is important to enable gifted students to discover new topics required by the age, and to offer educational opportunities in line with their interests and abilities. AI, which is one of the most important developments of our age, has begun to take its place in the background of many systems. It is important for gifted students who are interested in this subject to know what AI is and how it works, so that they can solve the problems they encounter.

In BİLSEMs, there are a total of 19 fields that students who are diagnosed with general mental ability can take. These areas are classroom teaching, science and technology, primary school mathematics, guidance, social studies, technology design, Turkish, foreign language, information technologies and software, visual arts, music, Turkish language and literature, biology, geography, philosophy, physics, chemistry, high school mathematics and history (MEB, 2022c). There is a framework program for each field. These framework programs offer BİLSEM teachers a pool of skill-oriented acquisitions for the gifted students in their groups to take advantage of by taking into account their individual differences (Göksu, 2021).

Akbaş & Tortop (2015) state that the framework programs that provide resources for teachers in BİLSEMs are not a complete program in terms of acquisition and evaluation, although this situation leaves BİLSEM teachers free to teach, if they are educationally inadequate, it causes them to make wrong practices, and that most of the applications made are enrichment practices. Göksu (2021) states that these framework programs created for BİLSEMs are formed according to the parallel curriculum model, curriculum narrowing model and integrated curriculum model strategies, which are among the curriculum differentiation models, and that the framework programs are based on enriching and deepening among the curriculum differentiation strategies.

There are nine modules in the framework program prepared for the ÖYG (Special Talents Development Program) program in the field of information technologies and software. While preparing Individualized Education Programs (BEP), teachers can include the subjects in these modules into their plans, taking into account the individual characteristics of the students. The topics under the AI module, which is one of these modules are introduction to AI, AI in daily life, agents, search algorithms, artificial neural networks, introduction to ML, classification in ML, clustering in ML, deep learning (MEB, 2022b). It is seen that the topics in the module cover most of the topics related to artificial intelligence and there are general gains related to the topics. The fact that the subject of AI is included as a module in the framework program prepared for the field of information technologies and software in BİLSEMs indicates the need for this issue in the education of gifted students. For gifted students who want to work on AI (especially for those who are new to AI), it is seen that it would be useful to present a framework teaching program that guides information technologies and software teachers about which AI topics to start with and how a hierarchical structure can be followed.

Another important issue is that teachers in BİLSEMs can also open elective field/activity/skill development workshops apart from the basic fields in which students are educated. The education programs of the elective fields are prepared by the relevant elective field/activity/talent development workshop teacher in accordance with the age and cognitive levels of the students and applied after they are approved by the BİLSEM management. In the annex of the BİLSEM directive, there are 30 elective courses/activity/talent development workshops that can be taken by students who are diagnosed according to the general mental ability field. Some of these are mind games, astronomy, aviation and space, robotics, software development. BİLSEM administrations can add new workshops to these workshops, which are included in the annex to the directive, by taking advantage of local opportunities within their possibilities and by obtaining the approval of the General Directorate (MEB, 2022c). Different talent workshops are established in BİLSEMs, taking into account their physical conditions. A cooperation protocol was signed between the Ministry of National Education and Vakıfbank for the construction of AI workshops, which is one of these workshops. The Minister of National Education stated that 15 AI workshops would be established in the first place (MEB, 2022d). This situation will reveal the need for resources for teachers who will provide AI training in these workshops.

In this study, based on institutional goals and social needs, it is aimed to prepare a beginning level AI framework curriculum for the 6th-10th grade gifted students, as a guiding recommendation for teachers. The problem situation that is aimed to be answered in the study is as follows: Which subjects should be included in the framework curriculum to be prepared for gifted students at the 6th -10th grade level who will just start their studies on AI in order to teach basic concepts, ethical, mathematical and statistical dimensions of AI?

METHOD

Research Design

The process of developing an educational program essentially corresponds to a design-based research. This study was also structured as a design-based research; however, current research was limited to needs analysis and design dimensions. In the needs analysis stage, the content analysis of the existing curriculum and in the design stage, quantitative analyzes based on expert opinions were used. Within the scope of the needs analysis, 54 structured undergraduate and graduate level curriculum of 41 different universities that can be accessed through searches on the google search engine with the keywords "Artificial Intelligence Syllabus" and "Machine Learning Syllabus" were examined. Since the main purpose of the study is to teach students the mathematical and statistical dimensions of AI algorithms, the subjects in undergraduate and graduate courses of universities were analyzed in order to create a wide subject list regarding these subjects. A subject list was created by examining the subjects included in the courses and the frequency of these subjects. In the design phase, the prepared subject list was presented to the experts and their opinions were received.

The "Artificial Intelligence Curriculum Subjects Determination Form for 6th Grade - 10th Grade Gifted Students", which includes the subject list, was sent to the experts via e-mail and their opinions were received. In the form sent to the experts, a one-page explanation was made about the purpose of the study. In this statement, brief information is given about the BİLSEMs where the gifted students, the target group of the study, are educated in Türkiye. Afterwards, experts were asked to mark the subjects that they deem appropriate to be included in the framework curriculum for the sixth grade - 10th grade gifted students from AI and ML subjects in the form presented to them, according to certain evaluation criteria. Evaluation criteria that experts were asked to consider; (1) students' readiness level (especially in the field of mathematics), (2) taking account two lesson hours a week and a 16-week period (32 lesson hours in total), (3) students' not having received AI training before, and (4) that no programming language will be taught. It was also stated that the calculations regarding the subjects to be included in the curriculum would be made manually or by using simple calculation tools (such as Excel). Experts were specifically asked to consider these issues while marking the subjects in the subject determination form. By analyzing the opinions of experts, the subjects to be included in the AI framework curriculum were determined. In the final stage, learning domains, sub-learning domains and acquisitions related to the subjects were determined.

Study Participants

Opinions of 20 experts were received in the study. While determining the experts, attention was paid to their knowledge in different areas of AI and ML. In addition, it was ensured that the experts included university lecturers and teachers working in the Ministry of National Education. Panel information on these experts is given in Table 8.

Table 8. Panel information on experts

		Number
Institution	University	14
	The Ministery of National Education	6
Field of study[4]	Educational Technologies/Instructional Technologies	7
	Information and communication Technologies	3
	Educational Data Mining/Learning Analytics	2
	Artificial Intelligence	2
	Intelligent Tutoring Systems	1
	Machine Learning	1
	Adaptive Systems	1
	Robotic Coding	1
	Software/hardware	1
	Text Mining	1

As seen in Table 8, 14 of the 20 experts participating in the research are university faculty members and six are teachers at the Ministry of National Education. Additionally, the table shows that the experts participating in the study have different fields of work.

Analysis of Data

The content validity ratios (CVR) for the marking status of the subjects in the subject determination form from 20 experts were calculated. The subjects that were above the minimum value in the CVRs were determined and the content validity index (CVI)

[4] The information of study field is based on self- declaration of experts.

was calculated. In addition, hierarchical clustering analysis was performed for the subjects marked in the subject determination form by the experts, and the clustering status of the subjects was analyzed.

Based on content validity ratios and hierarchical clustering analysis, prominent subjects were revealed. As a result of the evaluations based on these subjects, learning areas and sub-learning areas were determined for the 16-week framework curriculum. Afterwards, each AI subject related to each learning area and sub-learning area was examined in detail and it was determined which concepts were included and which calculations were made for each subject separately. Later, taking main purpose of the prepared curriculum, the characteristics of the subjects and the knowledge levels of the students into account, target acquisitions were created for each subject.

FINDINGS

This study is based on analysis based on expert data. However, in order to obtain a structured form for expert opinions, an AI subject list was created, and then the experts were asked which of these subjects were suitable for the target audience. To create the subject list; access was provided to 54 AI and ML course curriculum at undergraduate and graduate levels from 41 different universities. Information on the courses accessed is given in Table 9.

Table 9. AI and ML courses and number of subjects in universities

University	Course Name	Number of Subjects
Birla Institute of Technology and Science	Artificial Intelligence and Machine Learning	38
Indian Institute of Technology Bombay	Introduction to Machine Learning	21
King Abdullah University of Science and Technology	Machine Learning	13
	Specific Topics in Artificial Intelligence	13
McGill University	Machine Learning	18
MIT	Artificial Intelligence	23
	Machine Learning	24
New York University	Introduction to Machine Learning	23
	Foundations of Machine Learning	14
Princeton University	Introduction to Machine Learning	21
Temple University	Machine Learning and Pattern Recognition	37
The Georgia Institute of Technology	Machine Learning	17
Tufts University	Introduction to Machine Learning	9
University at Buffalo	Introduction to Machine Learning	14
University Buelvard	Advanced Artificial Intelligence	12
University of Bilkent	Introduction to Machine Learning	19
	Artificial Intelligence	14
University of Cambridge	Machine Learning and Algorithms for Data Mining	5
	Artificial Intelligence I	8
University of Çankaya	Artificial Intelligence	20
University of Harvard	Artificial Intelligence	23
University of Manchester	Foundations of Machine Learning	7
University of Pompeu Fabra	Machine Learning	11
University of Simon Fraser	Machine Learning	7
University of Standford	Artificial Intelligence: Principles and Techniques	8
University of Uppsala	Artificial Intelligence	6
University of Washington in St. Louis	Introduction to Artificial Intelligence	20
University of Washington State	Introduction to Machine Learning	31
	Artificial Intelligence	9
University of AIZU	Artificial Intelligence	14
University of California, Berkeley	Introduction to Machine Learning	18
	Introduction to Artificial Intelligence	12
University of California, Los Angeles	Introduction to Machine Learning	25
	Introduction to Artificial Intelligence	14
University of Carnegie Mellon	Artificial Intelligence	27

	Machine Learning	28
	Introduction to Machine Learning	24
University of Clemson	Artificial Intelligence	9
University of Hacettepe	Fundamentals of Artificial Intelligence	13
University of Minesota Duluth	Artificial Intelligence	15
University of North Carolina	Introduction to Machine Learning	12
University of Northheastern	Artificial Intelligence	23
University of Oxford	Advanced Topics in Machine Learning	14
	Artificial Intelligence	10
University of Puerto Rico	Artificial Intelligence	8
University of Rochester	Introduction to Artificial Intelligence	7
University of Southern California	Machine Learning	13
	Introduction to Artificial Intelligence	25
University of Texas at Austin	Artificial Intelligence	16
University of Toledo	Machine Learning	11
University of Toronto	Introduction to Machine Learning	26
	Artificial Intelligence	11
University of Warwick	Machine Learning	10
University of Wisconsin Madison	Machine Learning	8

As seen in Table 9, 25 of the 54 AI and ML courses are artificial intelligence, 28 of them are ML courses and one of them is AI and ML course. Information on the frequency of the 25 AI and 28 ML courses in Table 9 is given in Table 10.

Table 10. Frequency of subjects in the current AI and ML curriculum of universities

Artificial Intelligence Courses			Machine Learning Courses		
Subjects	Frequency	%	Subjects	Frequency	%
Search	23	92	Support Vector Machine	21	72
Introduction to Artificial Intelligence	19	76	Introduction to Machine Learning	20	69
Constraint Satisfaction Problems (CSPs)/Problems Solving	16	64	Neural Networks	19	66
Games/Games Trees/Game Playing	13	52	Clustering	16	55
Learning	9	36	Logistic Regression	15	52
Markov Decision Processes/Markov Processes	8	32	Reinforcement Learning	15	52
Bayesian Network	8	32	Decision Trees	14	48
Neural Networks	8	32	Linear Regression	12	41
Propositional Logic	8	32	Regularization	11	38
Machine learning	8	32	Kernels	9	31
Reasoning	8	32	Dimensionality Reduction	9	31
Knowledge Representation	7	28	Deep Learning	9	31
Planning	7	28	Principal Component Analysis	8	28
Probabilistic	7	28	Boosting	8	28
Agents	7	28	K- Nearest Neighbors (Knn)	8	28
First-Order Logic	7	28	Probability	7	24
Knowledge Representation	7	28	Ensemble Methods	7	24
Uncertainty	6	24	Graphical Models	7	24
Probability	6	24	Naive Bayes	6	21
Reinforcement Learning	6	24	Unsupervised Learning Conceptual Knowledge	6	21
Hidden Markov Models	5	20	Feature Selection	5	17
Markov Models	5	20	Linear Classification	4	14
Deep Learning	3	12	Gradient Descent	4	14
Constraints	3	12	K-Means Clustering	4	14
			Hidden Markov Models	4	14
			Ensemble Learning	4	14

	Multi-Class Classification	3	10
	Computational Learning Theory	3	10
	Information Theory	3	10
	Supervised Learning Conceptual Knowledge	1	3

As seen in Table 10, the most common subjects in AI curriculum are search, introduction to AI, constraint satisfaction problems, problem solving and games. The most common subjects in ML curriculum are support vector machines, introduction to ML, neural networks, clustering, logistic regression and reinforcement learning. A subject list was created by bringing together the subjects of AI and ML in Table 10.

The experts were sent the "Artificial Intelligence Curriculum Subject Determination Form for 6th grade - 10th Grade Gifted Students", which includes the subject list, and they were asked to mark the subjects in the subject list according to certain evaluation criteria, and to write the subjects they would like to add in the other section, apart from these subjects. Here, the following points were determined as the evaluation criteria for the opinions of the experts:

1. The readiness level of students (especially in mathematics),
2. Considering two course hours per week and a 16-week period (32 course hours in total),
3. Students' not having received AI training before
4. that no programming language will be taught.

The number of subjects (NG) and CVR values marked by the experts are given in Table 11. CVRs were calculated with the following formula (Lawshe, 1975).

$$CVR = \frac{NG}{N/2} - 1$$

NG= The number of experts marking the subject

N= The total number of experts participating

Table 11. CVR Values of AI subjects according to expert opinion[5]

N	N_G	Subjects	CVR
1	19	Introduction to Artificial Intelligence	0.90
2	18	Probability	0.80
3	18	Supervised Learning Conceptial Knowledge	0.80
4	17	Decision Trees	0.70
5	16	Unsupervised Learning Conceptial Knowledge	0.60
6	16	K- Nearest Neighbors (Knn)	0.60
7	15	Clustering	0.50
8	15	Naive Bayes	0.50
9	14	Reinforcement Learning	0.40
10	12	Linear Classification	0.20
11	11	Linear Regression	0.10
12	11	Logistic Regression	0.10
13	10	Foundations of Bayesian Networks	0.00
14	9	Feature Selection	-0.10
15	9	K-Means Clustering	-0.10

The content validity criterion was used to determine whether each subject predicted to be in the "AI curriculum" by the experts was statistically significant. Since there were 20 experts in this study, the critical value (0.05 significance level) for the content validity criterion was determined as 0.42 (Veneziano & Hooper, 1997). From this point of view, it is seen in Table 11 that according to the opinions of 20 experts, there are eight subjects with the minimum value of CVR and above.

The content validity index (CVI) must be calculated to see if the content validity is statistically significant. CVI is calculated by taking the average of the CVR values of the items decided to be included (Lawshe, 1975). Based on this, the CVI was found to be 0.68 by taking the average of the CVR values of eight subjects whose CVR values were at or above the minimum value (Table 12).

[5] This table includes the CVR values for the first 15 subjects, and the full table is in Appendix-1.

Table 12. Content validity index of the subjects

N.	NG	Subjects (Learning Domains)	CVR
1	19	Introduction to Artificial Intelligence	0.90
2	18	Probability	0.80
3	18	Supervised Learning Conceptial Knowledge	0.80
4	17	Decision Trees	0.70
5	16	Unsupervised Learning Conceptial Knowledge	0.60
6	16	K- Nearest Neighbors (Knn)	0.60
7	15	Clustering	0.50
8	15	Naive Bayes	0.50
The content validity index			0.68

The content validity index and the content validity ratios are defined as the consistency among experts on the issues that experts find important (Yurdugül & Bayrak, 2012). It is seen that the content validity index is greater than the content validity criterion (0.68>0.42). Therefore, the content validity of the subjects is statistically significant.

Hierarchical clustering analysis was also applied in addition to the dataset, which included the subjects that the experts marked from the subject list. Although there is a great deal of similarity between the content validity ratios in Table 12 and the results of the clustering analysis given in Appendix-2, minor differences have emerged between them. According to this, 13 subjects were obtained in the grouping made by cluster analysis while 8 subjects were determined according to the cut-off points based on CVRs. The five subjects that differ are as follows: a) reinforcement learning, b) logistic regression, c) linear regression d) linear classification and e) Foundations of Bayesian Networks.

The process of examining the AI subjects that emerged as a result of both analyses, determining the subjects to be included, determining the learning domains and sub-learning domains related to the subjects, and creating acquisition statements are given in the discussion, conclusion and recommendations section of the research. The learning domains, sub-learning domains and their related acquisitions are given in appendix-3 as the general findings of this research.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

There are studies on K-12 AI education in the literature, and these studies include educational frameworks and student competencies (AI4K12, 2018; Lao, 2020; Long & Magerko, 2020). In addition to this, there are AI curricula endorsed by governments in some countries, albeit in a small number. It is seen that these curriculum focus on different subjects related to AI and that AI subjects are included in the curriculum for different periods of time (Li, 2020; UNESCO, 2022).

In this study, a framework curriculum that includes the basic concepts of AI and the mathematical and statistical dimensions of AI for gifted students in 6th grade - 10th grades who are just starting to study AI is presented as a guide to teachers and some suggestions for future studies on AI education are put forward. The curriculum presented in the study is not associated with any technology or platform. This approach is consistent with UNESCO (2022)'s recommendation that curriculum should not be associated with specific technologies, brands or platforms. Williams, Kaputsos & Breazeal (2021) also mention the difficulties related to robot costs as a result of the AI curriculum they implemented. There is no obligation to use any robot set for the acquisitios in the AI curriculum presented in this study. Another important issue is whether coding is a part of AI education or not, as Li (2020) points out. It states that coding should not be a preliminary skill to start learning AI and that coding can be learned in other situations. The learning acquisitions in this study overlap with this understanding and do not take coding as a prerequisite. Another important point is the place of mathematics in AI education. UNESCO (2022) emphasizes that the AI development curriculum should be based on relevant subject expertise and the need for harmony between mathematical principles, coding and algorithms. For example; whereas Portugal places most of its AI learning outcomes in 'computational thinking' within the mathematics subject, China designs its ICT curriculum according to mathematics requirements from year to year (UNESCO, 2022). This information points to the importance of mathematical and statistical dimensions in AI education, and this study generally focuses on this point.

In this study, opinions were received from experts about the subjects that could be included in the AI curriculum to be created for gifted students in the sixth grade - 10th grades who are just starting to study artificial intelligence. Content validity was checked by calculating CVRs for the subjects marked by experts, and hierarchical clustering analysis was performed to examine which subjects were clustered. According to CVRs, it was observed that eight subjects were above the cut-off point (Appendix-1), and according to hierarchical clustering, 13 subjects were clustered (Appendix-2).

As a result of both analyses, there are eight subjects that overlap. These are introduction to AI, probability, supervised learning conceptual knowledge, unsupervised learning conceptual knowledge, clustering, k-nearest neighbor algorithm, decision trees and Naive Bayes algorithm. It can be seen that the subjects mainly consist of ML subjects. Unsupervised learning is a learning domain and there are sub-learning domains under it. Since distance-proximity calculations are used in ML algorithms and are a prerequisite for subsequent subjects, it was decided to include the subject of similarity and dissimilarity calculations as a sub-learning domain

under the unsupervised learning domain. Supervised learning, which experts agree on, is an ML subject and has been discussed in two contexts: classification and prediction. The knn algorithm, Naive Bayes classifier and decision trees included in both analyzes are classification methods. Linear regression, which is clustered within 13 subjects as a result of hierarchical clustering analysis, is a prediction method. Linear regression and knn regression subjects are also included under the heading of prediction in order not to disrupt the integrity of supervised learning domains. Again, the subject of Bayesian networks foundations which is included in 13 subjects as a result of hierarchical clustering was decided to be in the program because it is an inclusive subject and is related to the subject of probability and Naive Bayes, which experts have agreed on.

As a result, learning domains and sub-learning domains were determined for the AI framework curriculum for gifted students in line with the main objectives of the study and the teaching period (2 hours per week, 16 weeks). Both predecessor-successor relationships and horizontal-vertical relationships were observed between the subjects. In addition, the learning domains and sub-learning domains were finalized by taking into account the ordering of the cognitive skills required by the learning and sub-learning domains from simple to complex (Table 13). The determined learning domains correspond to the subject of "Computers can learn from data", which is the third of the five big ideas of AI4K12, (2018) and the subjects "general information about ML" and "knowledge of ML methods" under the title of knowledge within the ML education framework of Lao (2020). They also correspond to the fourth Competence “General vs. Narrow”, the nineth Competence “ML Steps”, the eleventh Competence “Data Literacy”, the twelfth Competence “Learning from Data” and the sixteenth Competence “Ethics” within the framework put forward by Long and Magerko (2020). They are in line with the domains of "Data literacy", "The ethics of AI" and "Understanding and using AI techniques", which are among the AI curriculum domains prepared by UNESCO (2022) to determine the duration of the subjects in the AI curriculum. The duration of the “Understanding and using AI techniques” domain in the curriculum endorsed by governments is between 0 and 128 hours (UNESCO, 2022). The AI framework curriculum put forward in this study is planned to be 32 lesson hours.

Table 13. AI curriculum learning domains and sub-learning domains for gifted students

1. INTRODUCTION TO AI
2. PROBABILITY
2.1. The Importance of Probability for AI
2.2. The Probability of Simple Events
2.3. Jointly Probability
2.4. Conditional Probability
2.5. Marginal Probability
2.6. Bayes Theorem
3. SUPERVISED AND UNSUPERVISED LEARNING
4. UNSUPERVISED LEARNING
4.1. Similarity and Dissimilarity Calculations
4.1.1. Similarity and Dissimilarity Calculations for Binary Measurements
4.1.2. Similarity and Dissimilarity Calculations for Quantitative Measurements
4.2. Clustering Analysis
5. SUPERVISED LEARNING
5.1. Classification
5.1.1. Knn (K-Nearest Neighbours) Algorithm
5.1.2. Naive Bayes Classifier
5.1.3. Decision Trees
5.2. Prediction
5.2.1. Linear Regression
5.2.2. Knn Regression
6. FOUNDATIONS OF BAYESIAN NETWORKS
6.1. Configuration of Bayesian Networks[6]
6.2. Bayesian Calculations
6.2.1. Calculations in three-node serial-connected networks
6.2.2. Calculations in three-node convergent networks
6.2.3. Calculations in three-node divergent networks

[6] The configuration of Bayesian networks is limited to three nodes.

As seen in Table 13, there are six learning domains and 22 sub-learning domains in the curriculum. After this stage, each AI subject related to the learning domains and the sub-learning domains in Table 13 were examined in detail and it was determined which concepts were included and which calculations were made for each subject separately. Then, acquisition statements were formed for learning domains and sub-learning domains based on conceptual knowledge, procedural knowledge and strategic knowledge in line with the students' prior knowledge and the main objectives of the study (Appendix-3).

Information technologies and software are among the fields that students in the field of general mental ability can take at BİLSEMs. Students can do AI studies in the field of information technologies and software. In addition, these students can work on AI in AI workshops opened by teachers. In this study, an AI framework curriculum was prepared to support studies in the field of information technologies and software and in the artificial intelligence workshop. The learning domains, sub-learning domains and acquisitions of the AI curriculum put forward in this study provide guidance for teachers who will start AI studies with their students. BİLSEM teachers are expected to include the subjects in the framework curriculum into their plans, taking into account factors such as students' interests, abilities and readiness. In this regard, it is clearly stated in the BİLSEM directive that education and training activities at BİLSEM will be carried out according to the "Individualized Education Program" to be prepared in line with the performances and educational needs of gifted students (MEB, 2022c).

The AI framework curriculum put forward in this study covers some of the subjects and student competencies related to AI education in the literature. In future research, a curriculum that includes other AI subjects and acquisitions can be developed to be compatible with the AI subjects and student acquisitions revealed in this study. As UNESCO (2022) points out, the AI curriculum needs to be further tested and improved by publishing the results. There is a need to design, implement and evaluate the results of many different teaching activities in accordance with the AI curriculum, subjects and acquisitions presented in this study.

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

This research was conducted with the approval of Hacettepe University Ethics Committee, dated 12.04.2021 and numbered E-35853172-300-00001536110.

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Appendix-1

CVR Values of AI subjects according to expert opinion

S.	N_G	Subjects	CVR
1	19	Introduction to Artificial Intelligence	0.90
2	18	Probability	0.80
3	18	Supervised Learning Conceptual Knowledge	0.80
4	17	Decision Trees	0.70
5	16	Unsupervised Learning Conceptual Knowledge	0.60
6	16	K-Nearest Neighbors (Knn)	0.60
7	15	Clustering	0.50
8	15	Naive Bayes	0.50
9	14	Reinforcement Learning	0.40
10	12	Linear Classification	0.20
11	11	Linear Regression	0.10
12	11	Logistic Regression	0.10
13	10	Foundations of Bayesian Network	0.00
14	9	Feature Selection	-0.10
15	9	K-Means Clustering	-0.10
16	8	Neural Networks	-0.20
17	8	Deep Learning	-0.20
18	7	Support Vector Machines	-0.30
19	7	Information Theory	-0.30
20	7	Search	-0.30
21	6	Gaussian Bayes	-0.40
22	6	Graphical Models	-0.40
23	6	Computational Learning Theory	-0.40

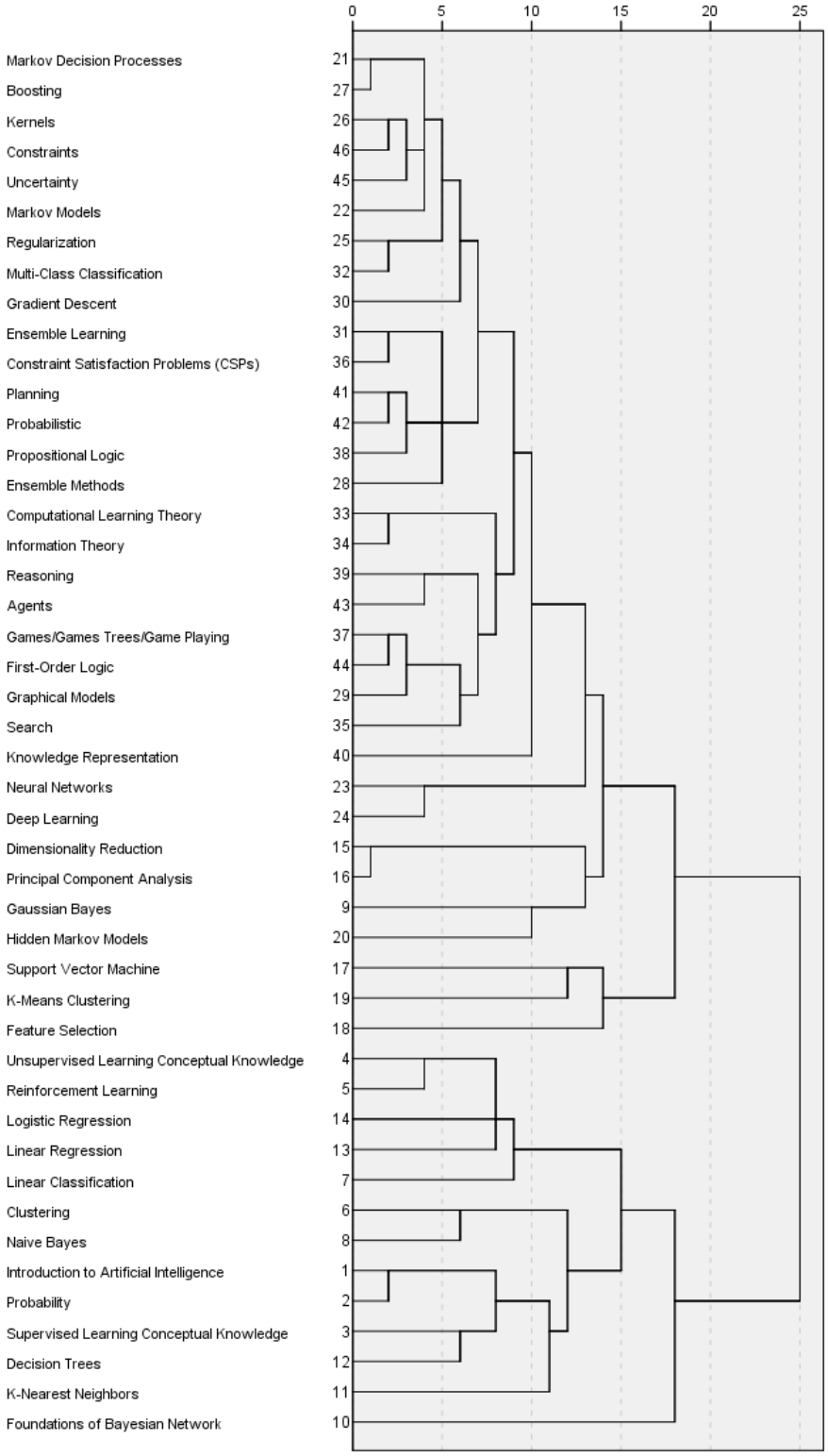
S.	N_G	Konular	KGO
30	4	Agents	-0.60
31	4	First-Order Logic	-0.60
32	3	Hidden Markov Models	-0.70
33	3	Multi-Class Classification	-0.70
34	3	Constraint Satisfaction Problems (CSPs)	-0.70
35	3	Probabilistic	-0.70
36	2	Markov Models	-0.80
37	2	Regularization	-0.80
38	2	Ensemble Methods	-0.80
39	2	Gradient Descent	-0.80
40	2	Ensemble Learning	-0.80
41	2	Planning	-0.80
42	2	Uncertainty	-0.80
43	2	Constraints	-0.80
44	1	Kernels	-0.90
45	1	Other: Fuzzy Logic	-0.90
46	1	Other: ZeroR	-0.90
47	1	Other: OneR	-0.90
48	1	Other: Artificial Intelligence and Ethics	-0.90
49	1	Other: Sequential Analysis	-0.90
50	1	Other: Association Rules	-0.90
51	1	Other: Classification	-0.90
52	1	Other: Natural Language Processing	-0.90

24	5	Games/Games Trees/Game Playing	-0.50
25	5	Knowledge Representation	-0.50
26	4	Dimensionality Reduction	-0.60
27	4	Principal Component Analysis	-0.60
28	4	Propositional Logic	-0.60
29	4	Reasoning	-0.60

53	1	Other: Image Recognization	-0.90
54	1	Other: Expert Systems	-0.90
55	1	Other: Prolog	-0.90
56	0	Markov Decision Processes/Markov Processes	-1
57	0	Boosting	-1

Appendix-2

Hierarchical clustering analysis of AI subjects according to expert opinions



Appendix-3

Learning areas, sub-learning areas and acquisitions that make up the artificial intelligence (AI) framework curriculum for gifted students

SUBJECTS	ACQUISITIONS
1. INTRODUCTION TO AI	1.1. Comprehends what AI is. 1.2. Comprehends the working areas of AI. 1.3. Analyzes the disciplines that contribute to AI. 1.4. Distinguishes between general and narrow AI. 1.5. Comprehends the ethical issues that must be followed in AI applications.
2. PROBABILITY	
2.1. The Importance of Probability for Artificial Intelligence 2.2. Probability of Simple Events 2.3. Jointly Probability 2.4. Conditional Probability 2.5. Marginal Probability 2.6. Bayes Theorem	2.1.1. Comprehends the importance of probability for AI. 2.2.1. Determines the possible situations of an event.[7] 2.2.2. Distinguishes events with "more", "equal", "less" probability.[7] 2.2.3. Calculates the probability of a simple event.[7] 2.3.1. Explains the concept of jointly probability. 2.3.2. Comprehends how to calculate the jointly probability in a given problem. 2.3.3. Calculates the jointly probability in a situation where more than one event occurs. 2.4.1. Explains the concept of conditional probability. 2.4.2. Comprehends how conditional probability is calculated in a given problem. 2.4.3. Calculates the conditional probability for a given sample situation. 2.5.1. Explains the concept of marginal probability. 2.5.2. Comprehends how marginal probability is calculated in a given problem. 2.5.3. Calculates the marginal probability for a given sample situation. 2.6.1. Explains how Bayes' rule is obtained. 2.6.2. Comprehends how to calculate probability using Bayes' rule in a given problem. 2.6.3. Performs the necessary probability calculations using Bayes rule in a given problem related to daily life.
3. SUPERVISED AND UNSUPERVISED LEARNING	3.1. Comprehends what machine learning is. 3.2. Comprehends what unsupervised learning is. 3.3. Comprehends that different methods are used in unsupervised learning. 3.4. Comprehends what supervised learning is. 3.5. Comprehends that different methods are used in supervised learning. 3.6. Explains the difference between unsupervised learning and supervised learning.
4. UNSUPERVISED LEARNING	
4.1. Similarity and Dissimilarity Calculations	
4.1.1. Similarity and Dissimilarity Calculations for Binary Measurements	4.1.1.1. Explains what the similarities and dissimilarity of entities mean. 4.1.1.2. Comprehends what quantitative measurement and binary measurement are. 4.1.1.3. Comprehends that the concepts of similarity and dissimilarity are expressed mathematically as proximity and distance. 4.1.1.4. Comprehends which distance measures are used for binary measurements. 4.1.1.5. Finds the most similar and most dissimilar entities in a given problem using binary distance measures.
4.1.2. Similarity and Dissimilarity Calculations for Quantitative Measurements	4.1.2.1. Comprehends that the concepts of similarity and dissimilarity are expressed mathematically as proximity and distance. 4.1.2.2. Comprehends which distance measures are used for quantitative measurements. 4.1.2.3. Finds the most similar and most dissimilar entities in a given problem using quantitative distance measures.
4.2. Clustering Analysis	4.2.1. Comprehends what clustering is. 4.2.2. Comprehends that there are different clustering methods. 4.2.3. Explains what the hierarchical clustering method is. 4.2.4. Comprehends the process steps of hierarchical clustering method. 4.2.5. Clusters a given sample data set using the hierarchical clustering method. 4.2.6. Gives examples of the use of clustering method in daily life.
5. SUPERVISED LEARNING	
5.1. Classification	
5.1.1. Knn (K-Nearest Neighbor) Algorithm	5.1.1.1. Explains the Knn algorithm. 5.1.1.2. Runs Knn algorithm on sample data step by step. 5.1.1.3. Gives an example of the application of Knn algorithm in daily life.
5.1.2. Naive Bayes Classifier	5.1.2.1. Explains the Naive Bayes algorithm.

[7] In writing this acquisition statement, the eighth grade mathematics curriculum of the Ministry of National Education was used (MEB, 2018b).

SUBJECTS	ACQUISITIONS
	5.1.2.2. Runs Naive Bayes algorithm on sample data step by step. 5.1.2.3. Gives an example of the application of Naive Bayes algorithm in daily life.
5.1.3. Decision Trees	5.1.3.1. Gives examples of the most commonly used algorithms for building decision trees. 5.1.3.2. Discovers that a tree-shaped classification structure is formed as a result of decision tree analysis. 5.1.3.3. Comprehends that entropy is a measure of uncertainty that addresses randomness and contingency probabilities. 5.1.3.4. Comprehends that entropy is a guide in the calculation of information gain. 5.1.3.5. Calculates entropy using the appropriate formula for a given sample situation. 5.1.3.6. Comprehends how to calculate the information gain by obtaining the entropy value. 5.1.3.7. Discovers the importance of entropy and the information gain for decision tree algorithms. 5.1.3.8. Creates the decision tree structure by performing the necessary calculations for a given sample dataset. 5.1.3.9. Gives an example of a situation where the decision tree can be used in daily life.
5.2. Prediction	
5.2.1. Linear Regression	5.2.1.1. Comprehends that in linear regression, the value of the dependent variable is the variable we want to explain and the independent variable is the explanatory variable. 5.2.1.2. Discovers that thanks to the mathematical equation to be obtained with linear regression, the level of effect of the change to be made on the independent variable on the dependent variable can be determined. 5.2.1.3. Comprehends that the equation for the line drawn in linear regression is expressed as y = a + bx. 5.2.1.4. Calculates the a value, b value and R2 value in the equation y = a + bx by using the data of the dependent and independent variable in an example given from daily life. 5.2.1.5. Interprets the equation y=a+bx and the R2 value by making the necessary calculations in a given example.
5.2.2. Knn Regression	5.2.2.1. Explains how Knn Regression works. 5.2.2.2. Runs Knn Regression on sample data step by step. 5.2.2.3. Predicts an unknown feature by exploiting the known feature of a new observation added to a real-life dataset and applying knn regression..
6. FOUNDATIONS OF BAYESIAN NETWORKS	
6.1. Configuration of Bayesian Networks	6.1.1. Comprehends that the structure showing nodes and the connections between nodes is called a graph. 6.1.2. Comprehends how the events we encounter in daily life can be shown with a causal network. 6.1.3. Discovers the relationship between causal networks and graphs. 6.1.4. Discovers that Bayesian networks are composed of variables and directional links that connect variables to each other. 6.1.5. Discovers that Bayesian networks consist of non-cyclic directed graphs. 6.1.6. Discovers serial, convergent and divergent connections in Bayesian networks.
6.2. Bayesian Calculations	6.2.1. Calculates the marginal probabilities of variables in a Bayesian network. 6.2.2. Calculates the jointly probabilities of variables in a Bayesian network. 6.2.3. Calculates the conditional probabilities of variables in a Bayesian network. 6.2.4. Comprehends what it means to make predictions in a Bayesian network. 6.2.5. Comprehends what diagnosis is in a bayesian network. 6.2.6. Comprehends that factorization is used in Bayesian networks to calculate jointly probability and that the product rule is valid. 6.2.7 Calculates the jointly probability by factorization in a Bayesian network. 6.2.8. Comprehends that marginalization is used to calculate marginal probability and that the sum rule is valid. 6.2.9. Calculates the marginal probability by marginalizing in a Bayesian network. 6.2.10. Performs probability calculations based on prediction based on variables given in a bayesian network. 6.2.11. Performs probability calculations based on diagnosis based on the variables given in a bayesian network.

Özel Yetenekli öğrenciler için yapay zekâ öğretim programını oluşturan öğrenme alanları, alt öğrenme alanları ve kazanımlar

KONULAR	KAZANIMLAR
1. YAPAY ZEKÂYA GİRİŞ	1.1. Yapay zekânın ne olduğunu kavrar. 1.2. Yapay zekânın çalışma alanlarını kavrar. 1.3. Yapay zekâya katkı sunan disiplinleri analiz eder. 1.4. Genel ve dar yapay zekâ arasında ayrım yapar. 1.5. Yapay zekâ uygulamalarında uyulması gereken etik hususları kavrar.
2. OLASILIK	
2.1. Olasılığın Yapay Zekâ İçin Önemi 2.2. Basit Olayların Olma Olasılığı 2.3. Birleşik Olasılık 2.4. Koşullu Olasılık 2.5. Marjinal Olasılık 2.6. Bayes Teoremi	2.1.1. Olasılığın yapay zekâ için önemini kavrar. 2.2.1. Bir olaya ait olası durumları belirler.[8] 2.2.2. “Daha fazla”, “eşit”, “daha az” olasılıklı olayları ayırt eder.[8] 2.2.3. Basit bir olayın olma olasılığını hesaplar.[8] 2.3.1. Birleşik olasılık kavramını açıklar. 2.3.2. Verilen bir problemde birleşik olasılığın nasıl hesaplandığını kavrar. 2.3.3. Birden fazla olayın gerçekleştiği bir durumdaki birleşik olasılığı hesaplar. 2.4.1. Koşullu olasılık kavramını açıklar. 2.4.2. Verilen bir problemde koşullu olasılığın nasıl hesaplandığını kavrar. 2.4.3. Verilen örnek bir durumla ilgili koşullu olasılığı hesaplar. 2.5.1. Marjinal olasılık kavramını açıklar. 2.5.2. Verilen bir problemde marjinal olasılığın nasıl hesaplandığını kavrar. 2.5.3. Verilen örnek bir durumla ilgili marjinal olasılığı hesaplar. 2.6.1. Bayes kuralının nasıl elde edildiğini açıklar. 2.6.2. Verilen bir problemde bayes kuralının kullanılarak olasılık hesabının nasıl yapıldığını kavrar. 2.6.3. Günlük yaşamla ilgili verilen bir problemde bayes kuralını kullanarak gerekli olasılık hesaplamalarını yapar.
3. DENETİMLİ VE DENETİMSİZ ÖĞRENME	3.1. Makine öğrenmesinin ne olduğunu kavrar. 3.2. Denetimsiz öğrenmenin ne olduğunu kavrar. 3.3. Denetimsiz öğrenmede farklı yöntemlerin kullanıldığını kavrar. 3.4. Denetimli öğrenmenin ne olduğunu kavrar. 3.5. Denetimli öğrenmede farklı yöntemlerin kullanıldığını kavrar. 3.6. Denetimsiz öğrenme ve denetimli öğrenme arasındaki farkı açıklar.
4. DENETİMSİZ ÖĞRENME	
4.1. Benzerlik ve Farklılık Hesaplamaları	
4.1.1. İkili Ölçümler İçin Benzerlik ve Farklılık Hesaplamaları	4.1.1.1. Varlıkların benzerliklerinin ve farklılıklarının ne anlama geldiğini açıklar. 4.1.1.2. Nicel ölçüm ve ikili ölçümün ne olduğunu kavrar. 4.1.1.3. Benzerlik ve farklılık kavramlarının matematiksel olarak yakınlık ve uzaklık şeklinde ifade edildiğini kavrar. 4.1.1.4. İkili ölçümler için hangi uzaklık ölçülerinin kullanıldığını kavrar. 4.1.1.5. Verilen bir problemde ikili uzaklık ölçülerini kullanarak birbirine en çok benzeyen ve birbirinden en farklı varlıkları bulur.
4.1.2. Nicel Ölçümler İçin Benzerlik ve Farklılık Hesaplamaları	4.1.2.1. Benzerlik ve farklılık kavramlarının matematiksel olarak yakınlık ve uzaklık şeklinde ifade edildiğini kavrar. 4.1.2.2. Nicel ölçümler için hangi uzaklık ölçülerinin kullanıldığını kavrar. 4.1.2.3. Verilen bir problemde nicel uzaklık ölçülerini kullanarak birbirine en çok benzeyen ve birbirinden en farklı varlıkları bulur.
4.2. Kümeleme Analizi	4.2.1. Kümelemenin ne olduğunu kavrar. 4.2.2. Farklı kümeleme yöntemlerinin olduğunu kavrar. 4.2.3. Hiyerarşik kümeleme yönteminin ne olduğunu açıklar. 4.2.4. Hiyerarşik kümeleme yönteminin işlem adımlarını kavrar. 4.2.5. Verilen örnek bir veri kümesinde hiyerarşik kümeleme yöntemini kullanarak kümeleme yapar. 4.2.6. Kümeleme yönteminin günlük yaşamda kullanımına örnek verir.
5. DENETİMLİ ÖĞRENME	
5.1. Sınıflama	
5.1.1. Knn (K-En Yakın Komşu) Algoritması	5.1.1.1. Knn algoritmasını açıklar. 5.1.1.2. Örnek veri üzerinde Knn algoritmasını adım adım işletir. 5.1.1.3. Günlük yaşamda Knn algoritmasının uygulanmasına örnek verir.
5.1.2. Naive Bayes Sınıflandırıcı	5.1.2.1. Naive Bayes algoritmasını açıklar. 5.1.2.2. Örnek veri üzerinde Naive Bayes algoritmasını adım adım işletir. 5.1.2.3. Günlük yaşamda Naive Bayes algoritmasının uygulanmasına örnek verir.

[8] Bu kazanım ifadesinin yazımında MEB 8. sınıf matematik dersi öğretim programından yararlanılmıştır (MEB, 2018b).

KONULAR	KAZANIMLAR
5.1.3. Karar Ağaçları	5.1.3.1.Karar ağaçlarının oluşturulmasında en çok kullanılan algoritmalara örnekler verir. 5.1.3.2.Karar ağacı analizleri sonucunda ağaç şeklinde sınıflandırma yapısının oluştuğunu keşfeder. 5.1.3.3. Entropinin, rastlantısallığın ve beklenmeyen durum olasılıklarının ele alındığı bir belirsizlik ölçüsü olduğunu kavrar. 5.1.3.4. Entropinin bilgi kazancının hesaplanmasında yol gösterici olduğunu kavrar. 5.1.3.5. Verilen örnek bir durum için uygun formülü kullanarak entropiyi hesaplar. 5.1.3.6. Entropi değerinin elde edilmesi ile bilgi kazanımının nasıl hesaplanacağını kavrar. 5.1.3.7. Entropi ve bilgi kazanımının karar ağaçları algoritmaları için önemini keşfeder. 5.1.3.8. Verilen örnek bir veri kümesi için gerekli hesaplamaları yaparak karar ağacı yapısını oluşturur. 5.1.3.9. Günlük yaşamda karar ağacının kullanılabileceği bir duruma örnek verir.
5.2. Kestirim	
5.2.1. Doğrusal Regresyon	5.2.1.1. Lineer regresyonda bağımlı değişkenin değerini açıklamak istediğimiz değişken, bağımsız değişkenin ise açıklayıcı değişken olduğunu kavrar. 5.2.1.2. Lineer regresyon ile elde edilecek matematiksel eşitlik sayesinde bağımsız değişken üzerinde yapılacak değişikliğin, bağımlı değişken üzerindeki etki düzeyinin belirlenebileceğini keşfeder. 5.2.1.3. Lineer regresyonda çizilen doğruya ilişkin denklemin y=a+bx şeklinde ifade edildiğini kavrar. 5.2.1.4. Günlük yaşamdan verilen bir örnekte bağımlı ve bağımsız değişkene ait verilerden yararlanarak y=a+bx denklemindeki a değerini, b değerini ve R^2 değerini hesaplar. 5.2.1.5. Verilen bir örnekte gerekli hesaplamaları yaparak y=a+bx denklemini ve R^2 değerini yorumlar.
5.2.2. Knn Regresyon	5.2.2.1. Knn Regresyonunun çalışma şeklini açıklar. 5.2.2.2. Örnek veri üzerinde Knn Regresyonunu adım adım işletir. 5.2.2.3. Gerçek yaşamdan elde edilen veri kümesine yeni eklenen bir gözlemin bilinen özelliğinden yararlanıp knn regresyonu işe koşarak bilinmeyen bir özelliği kestirebilir.
6. BAYES AĞLARININ TEMELLERİ	
6.1. Bayes Ağları Yapılandırması	6.1.1. Düğümler ve düğümler arasındaki bağlantıları gösteren yapıya graf denildiğini kavrar. 6.1.2. Günlük yaşamda karşılaştığımız olayların nedensel ağ ile nasıl gösterilebileceğini kavrar. 6.1.3. Nedensel ağlar ile graflar arasındaki ilişkiyi keşfeder. 6.1.4. Bayes ağlarının değişkenler ve değişkenleri birbirlerine bağlayan yönlü bağlardan oluştuklarını keşfeder. 6.1.5. Bayes ağlarının devirli olamayan yönlü graflardan oluştuğunu keşfeder. 6.1.6. Bayes ağlarındaki seri, yakınsak ve ıraksak bağlantıları keşfeder.
6.2. Bayesian Hesaplamalar	6.2.1. Bir bayes ağındaki değişkenlere ait marjinal olasılıkları hesaplar. 6.2.2. Bir bayes ağındaki değişkenlere ait birleşik olasılıkları hesaplar. 6.2.3. Bir bayes ağındaki değişkenlere ait koşullu olasılıkları hesaplar. 6.2.4. Bir bayes ağında kestirim yapmanın ne olduğunu kavrar. 6.2.5. Bir bayes ağında tanı koymanın ne olduğunu kavrar. 6.2.6. Bayes ağlarında faktörleştirmenin birleşik olasılığı hesaplamada kullanıldığını ve çarpım kuralının geçerli olduğunu kavrar. 6.2.7. Bir bayes ağında faktörleştirme yaparak birleşik olasılığı hesaplar. 6.2.8. Marjinalleştirmenin marjinal olasılığı hesaplamada kullanıldığını ve toplama kuralının geçerli olduğunu kavrar. 6.2.9. Bir bayes ağında marjinalleştirme yaparak marjinal olasılığı hesaplar. 6.2.10. Bir bayes ağında verilen değişkenlerden yola çıkarak kestirime dayalı olarak olasılık hesaplamalarını yapar. 6.2.11. Bir bayes ağında verilen değişkenlerden yola çıkarak tanı koymaya dayalı olarak olasılık hesaplamalarını yapar.