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Comparative Analysis of the Studies of Countries on AI Teaching

Ali Kürşat ERÜMİT*
Trabzon University, Education Faculty Department of Computer Education and Instructional Technology, Trabzon, Türkiye, Orcid: 0000-0003-4910-4989

Ümit CEBECİ
Karabük University School of Foreign Languages, Karabük, Türkiye, ORCID: 0000-0002-8421-799X

Sefa ÖZMEN
Trabzon University Çarşıbaşı Vocational School, Trabzon, Türkiye, ORCID: 0000-0002-8360-105X

Furkan KALYONCU
Trabzon University Çarşıbaşı Vocational School, Trabzon, Türkiye, ORCID: 0000-0003-2214-3347

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Today, artificial intelligence technologies, which are making their impact more felt in almost every field, have also increased the interest in teaching this field. Anticipating that artificial intelligence will have a much more effective role in the coming years, countries have started to make preparations for teaching artificial intelligence in schools in order to prepare trained human resources in this field. Countries such as China, India, Canada, and the USA, which see artificial intelligence teaching as a strategic priority rather than just a curriculum, have started teaching artificial intelligence in schools by making investments in artificial intelligence teaching with important technology companies and scientists. Analysing the studies carried out by countries around the world on teaching artificial intelligence can be guiding for educators, researchers and decision-makers working in this field. For this reason, in this study, it is aimed to comparatively examine the studies carried out by countries in terms of policy, strategy and curriculum on Artificial Intelligence (AI) teaching. Document analysis method was used in the study. In this context, the reports of international organizations and the documents on the websites of relevant institutions of 21 countries around the world, especially the ministries of national education, were examined according to the determined themes. In addition, the preferences of the countries for AI teaching were compared according to the themes, and suggestions were made for AI teaching in schools.

*Correspondency: +905325019250, kerumit@trabzon.edu.tr

Introduction

AI, which includes the studies carried out by machines to perform human-like behavior and decision-making processes, shows itself in many areas today (Zhang, et al., 2014). Especially in the last 10 years, AI has become a technology that has become widespread in many areas of daily life and is more preferred in order to make people's lives easier. The possibilities and potential of AI are seen in many areas from mobile phones to smart homes, from the health sector to wearable technologies. According to the Center for Data Innovation (2016), these opportunities and potential of AI appear in 14 different categories, mainly energy, industrial operations, agriculture, defense, education, health, and transportation.

As in many different sectors, there are many opportunities that AI can provide in the education sector. For example, applications such as 'duolingo', 'google translate' (natural language processors as a part of AI) are used for educational purposes (Su & Zhong, 2022), AI robots (humanoids) such as Yuki appear in educational environments (Tahiru, 2021) together with AI technologies in education. It aims to follow the learning status of students and create a learning environment suitable for them based on student data (Pokricakova, 2019). The use of AI in education is not only for teaching purposes, but also for monitoring the learning processes of students (Shaikh et al., 2021), assisting school administration and management process (Wang, 2021), managing students' time and responsibilities (Haderer & Ciolacu, 2022). These systems offer various learning paths to students, evaluate learning processes and strengthen learning by giving feedback to students (Ciolacu et al., 2019). The use of AI applications in education also increases the motivation of students (Kandlhofer et al., 2016), supports their commitment to the course or subject (Hasnine, et al. 2021), and facilitates the learning process by increasing their academic achievement (Alomari & Jabr, 2020).

On the very basis of AI teaching lays data science, data organization, data interpretation, and data processing (Burgsteiner et al., 2016). It also includes so called 21st century skills; problem solving, critical thinking, algorithmic thinking, computational thinking, etc. which are all related to the processes perceiving, decomposing, abstracting, organizing, and patterning data (ISTE, 2011). At this point, many countries have started various studies on AI teaching so that students can be aware of how they perform these processes, starting from the learning processes, to improve their cognitive skills and develop other related skills (CSTA, 2017; AI4K12, 2022; ISTE, 2018).

Data science, which can be considered as the basis of AI, also includes studies to ensure that similar processes are carried out by computers. Therefore, it is thought that starting AI teaching in schools from an early age can play an important role in the development of these cognitive skills (Williams et al., 2019). Southworth et al. (2023) state that as artificial intelligence becomes involved in many aspects of human life, there is a need not only to use artificial intelligence, but also to better understand its broad applications, usefulness, limitations, and biases. Ng et al., (2021) state that knowing and understanding the basic functions of artificial intelligence and using AI applications have become a part of digital literacy for all citizens in an increasingly smart society. Additionally, Loeckx (2016) suggests that artificial intelligence can reduce the burden of both teachers and students in educational environments and be an effective learning tool that provides effective learning experiences for students. Schiff (2022) states that many countries discuss the lack of trained individuals in the field of artificial

intelligence and that eliminating this deficiency and training experts in the field is a priority for many countries. At this point, there is a need for a curriculum design for artificial intelligence education that allows meaningful classroom activities of students according to the characteristics of the target audience and encourages positive applications and perspectives in terms of artificial intelligence technologies (Yang, 2022). In addition to the benefits that AI can provide, the increase in the accessibility of the hardware and algorithms used today, accessibility of the tools used for AI coding such as Code.org, Google, Scracth, Cognimates to provide opportunities for young learners, and the use of block-based or visual environments related to AI (Su & Zhong, 2022) has facilitated the inclusion of AI in the education process in schools. At this point, studies in the literature indicate that an education that will provide everyone with basic information about artificial intelligence and its ever-increasing applications is of critical importance (Southworth et al., 2023). Therefore, many countries around the world have initiated studies to teach AI in early ages of their students (Kim et al., 2021a). As technology continues to advance, the integration of artificial intelligence (AI) into various fields has become increasingly important. This has led to a growing emphasis on the development of AI curriculums in educational institutions. China's Ministry of Education announced the "Artificial Intelligence Innovation Action Plan for Higher Education Institutions" to encourage and support young people to participate in artificial intelligence studies and encourage students to teach artificial intelligence knowledge. The Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) formed a joint working group to develop national guidelines for teaching AI to K-12 students (Chiu & Chai, 2020). While these initiatives aim to contribute to the development of school curricula related to artificial intelligence; The inclusion of artificial intelligence subjects in the school curriculum is seen as an important global strategic initiative in the education of the next generation (Pedro et al., 2019).

On the other hand, in the last decade, countries such as the USA, Austria, China, India, and Canada took action to add AI teaching to their curriculum rom primary schools, and some countries have already started teaching processes with their materials and contents. In this study, it is aimed to examine existing K12 Artificial Intelligence teaching programs and strategies around the world, compare countries according to the emerging themes, and give suggestions for teaching artificial intelligence according to the findings.

In this study, it is aimed to examine existing K12 Artificial Intelligence teaching programs and strategies around the world, compare countries according to the emerging themes, and give suggestions for teaching artificial intelligence according to the findings. The findings section of the study was prepared with the data obtained as a result of examining the studies carried out by countries on artificial intelligence teaching. In order to compare countries, themes were created according to the findings and a discussion and results section was prepared according to the determined themes and suggestions were given.

Method

Research Design

In this study, the document analysis method was used because the websites of institutions and organizations working on AI teaching, international reports and the websites of the relevant ministries of the countries were examined and the situation was described within the framework of the determined purpose. Document analysis is a method recommended for descriptive analyzes in order to reveal the current situation by compiling the findings obtained from different data sources (Creswell, 2007). In this study, the document review process was carried out with 4 stages suggested by Merriam (2009); finding the appropriate documents, checking the originality of the documents, creating a systematic about coding and cataloging, and analyzing data.

The keywords revealed by the literature review were examined and determined by the 4 experts listed in Table 1(in the working group section). Accordingly, the document analysis process was initiated. In the process of finding the appropriate documents, Google, Google Scholar, and ScienceDirect databases were searched with the key words such as “ai curriculum”, “ai curricula”, “ai curriculum in country name”, “ai curricula in country name”, “ai curriculum for k-12”, “ai K12 syllabus”. As a result, it was seen that the studies intensified in 2018 and later. For this reason, studies published after 2018 were included in the document analysis process to examine AI teaching programs consisting of current topics, achievements and technologies. In order to ensure the inclusiveness of the research, the AI curricula of countries included in the UNESCO report (UNESCO, 2022) and the countries within the G-20 were also examined.

At the stage of checking the originality of the documents, official sources of countries and organizations were taken into consideration as primary sources. Among the resources reached, there are 27 reports, 8 research articles and 6 AI curricula. The data comes from these sources were included in the document analysis on a country basis and these sources are presented in the Appendix 1 of the study.

At the stage of creating a systematic on coding and cataloging, the reports, projects, documents, research, and websites of ministries of the countries, non-governmental organizations such as Google, Microsoft, Intel etc. and international institutions websites were examined in detail. At first, research was conducted on whether countries have developed an AI curriculum. As a result of the research, the curricula of the countries that had AI curriculum were examined with the document analysis form. Secondly, it was checked whether these countries that did not have AI curriculum had any strategy reports or official initiatives on AI teaching. If available, these reports or initiatives related to AI education in general were summarized in the study by giving importance to AI teaching at K12 level. Thirdly, academic publications of countries in the field of AI were searched, and then, these studies on AI are reviewed and summarized in the study.

In the data analysis process, content analysis, which is one of the qualitative data analysis techniques, was used in this study in order to find out emerging points of the written and visual sources (Fraenkel et al., 2012) by means of coding (Stemler, 2015). Thus, the content of the

documents included in the research process were examined and the data obtained was analyzed by means of content analysis in order to find out the studies of the countries on AI teaching.

Data Collection Tools

Document Review Form: The documents collected within the scope of the study were subjected to preliminary examination and the available data were analyzed. A document review form was developed by the researchers in order to make detailed examinations and analyze the curriculum on common points. The form developed by 3 researchers was submitted to the opinion of 3 field experts, including a professor, an associate professor and a doctor faculty member, and the document review form was finalized with the opinions received. Nine themes that can be considered common in the curriculum prepared by the researchers for the teaching of AI were determined. These themes are purpose of the curriculum, teacher training, beginning year of AI teaching, level-age-class, units, subjects, skills, and activities.

The documents to be examined were shared among researchers based on countries. The documents included in the research process were examined according to these themes and each researcher entered their data on the document review form regarding their own data. When the data entries were completed, the document was independently evaluated by all 3 researchers and necessary corrections and changes were made. Document analysis form is attached to Annex 1.

Study Group

This study was carried out during PhD. course named "AI Teaching at Schools" during the 2021-2022 Spring Semester of Computer and Instructional Technologies Education Doctorate Program. The working group (researchers) consists of a team of four people. Table 1 provides information about the researchers.

Table 1. Information on the Working Group

	Department	Title	Year of Experience
Researcher 1	Computer and Instructional Technologies Education	Associate Professor Doctor	19
Researcher 2	Computer Education and Instructional Technologies	Lecturer, PhD Student	12
Researcher 3	Computer and Instructional Technologies Education	Lecturer, PhD student	2
Researcher 4	Computer and Instructional Technologies Education	Lecturer, PhD student	2

The working group consists of an associate professor working in the department of Computer Education and Instructional Technologies and three researchers continuing their doctoral education in the same department and working as lecturers at different state universities.

Findings

In the study, the findings are organized in the form of presenting the strategies and curriculum developed by countries on AI. The document analysis process carried out within the scope of the study was carried out in a 4-stage structure, which is also stated in the method section. First, researchers (given in Table 1) identified keywords related to artificial intelligence curriculum studies. Each researcher individually conducted database searches using the specified keywords. As a result of these scans, studies related to the artificial intelligence curricula of the countries were identified. In the second stage, the originality of the obtained studies was checked. At this stage, all of the studies belong to the relevant countries and no documents with misleading or incorrect content have been found. In the third stage, the document review form in Annex 1 was developed for the purpose of examining the studies. At this stage, the documents were shared among the researchers and each researcher made an individual analysis using the document review form. During this process, the research group came together in weekly meetings, jointly evaluated and finalized the analyzes made. These meetings lasted 6 weeks. The findings obtained at the end of this process are given in this section. By describing the current situation of each country on AI, the strategies prepared for AI teaching are summarized or, if there is a curriculum developed, the content of the curriculum is explained.

Canada

When the studies on AI teaching across Canada are examined, it is seen that there are three attempts for the preparation of AI curriculum. One of these initiatives, “Learning for the Digital World: A Pan-Canadian K12 Computer Science Education Framework” was launched in 2018. The work is supported by the Canadian government and a private company, Amazon. Curriculum development for computer science is maintained by the Canada Learning Code (CLC), the national education aid group that provides technology education work for Canadians on a voluntary basis (CLC, 2022). K-12 curriculum development studies includes different specialist such as faculty members of higher education institutions, computer science and curriculum development doctoral students, private sector representatives. In this context, this initiation aims to handle the computer science curriculum within a national standard. Computer science curriculum for K12 students in Canada focuses on 5 points: “programming, computing and networks, data, technology, and society and design”.

The subjects that the curriculum focuses includes topics such as algorithms, data structures, hardware-software, cyber security, data storage, data visualization, AI and machine learning. The curriculum handles these topics by considering their benefits to individuals and public rather than focusing on their technical aspects. In addition, instead of suggesting a separate

curriculum for each class levels, it promotes student levels which are divided into five categories: beginners, developing, progressing, competent and more advanced.

In this study's case, AI teaching in this initiation is covered under the theme of Data, which is one of the five points of the curriculum. With the topics covered under the data theme, it is expected that students after high school education will acquire the skills and competences of "creating, storing, organizing and analyzing data" (K12csframework, 2020). Table 2 provides information on levels, skills, and proficiencies.

Table 2. AI and Machine Learning Theme Under Data Section of the Computer Science Framework. (Adapted from K12csframework, 2020)

Levels	Skills and Proficiencies
Beginners	Recognizes commonly used digital tools related to AI and machine learning and understands how such tools help humans to perform tasks that were previously specific to human.
Developing	It defines AI and gives real-life examples of how AI uses data to extract information from data.
Progressing	It explains the basic algorithms of AI systems and how data and machine learning interact.
Competent	Evaluates how human biases are embedded in technical and AI systems.
More Advanced Levels	Explain how machines learn. Discusses ethical issues related to machine learning and AI.

The digital and unplugged tools offered for use by educators in this curriculum are listed as follows; "Raspberry Pi, Voiceflow, Scratch, Little Robot Friends, Glitch, Arduino, CoSpaces, Trinket, Pixlr, Canva, Piskel, Soundtrap, TinkerCad, Micro:bit, SketchUp, Lynx, ScratchJr, BeeBot, Repl.it, Makecode, Art: bit, and The Algorithm Literacy Project" (K12 Computer Science Framework, 2022).

One of the other attempts to develop a curriculum for AI teaching in Canada is "Actua" that is specific to Canadian high schools. Actua is one of Canada's non-profit contributors to AI education and its curriculum development study was started in 2020 (Actua, 2020). Actua also continues its research on science and engineering in collaboration with 41 universities and colleges around the country.

With the support of Google and the Canadian Internet Registration Authority, Actua's AI teaching handbook was released in 2020. The themes covered in Actua's AI curriculum are based on the AI study of AI4K12 which is the AI teaching initiation of the USA (Actua, p.22, 2020). Actua prepared a curriculum proposal within the framework of the questions in Table 3 and aimed for students to achieve the skills indicated in Table 4.

Table 3. The questions that Actua addressed while preparing the curriculum within the framework of the themes.

Themes	Data	Perception	Representation and Reasoning	Learning	Natural Interaction	Social Impacts
Learning Questions	What is data and how do people use it? What are the data types used in data science? In what ways is data applied in careers and society?	How do machines use sensors to detect data? How do machine learning tools classify data? What are the limits of machine perception?	How is data used in AI models? How can models represent other concepts? How do machine models inform decision making?	How do algorithms exhibit learning? What are neural networks? How does training data affect machine learning?	What does the machine-human interaction look like? How do machines understand natural language? What is active computation? What is consciousness?	What ethical considerations arise when we use and create AI in society? What biases exist in AI algorithms? How can AI be used to face global challenges?

In Table 4, the levels for teaching AI within the framework of AI4K12 and the planned themes to be acquired at these levels are summarized.

Table 4. Skills targeted by Actua in the curriculum within the framework of the determined themes.

Themes	Data	Perception	Representation and Reasoning	Learning	Natural Interaction	Social Impacts
Skills	Knows that understanding data is the foundation of AI	Computers perceive the world and their environment	AI creates models to present (represent) concepts and uses these models for reasoning.	The machine learning happens with data over a period of time	AI mimics interaction between human to human and human to AI	AI can impact society in both positive and negative ways

Table 5. Levels determined by Actua in the curriculum within the framework of the themes.

Themes	Data	Perception	Representation and Reasoning	Learning	Natural Interaction	Social Impacts
Novice	Defines data, data sources or types	Identifies sensors (which interact with AI agents)	Creates models; uses decision trees	Uses a machine learning program; describes learning	Defines verbal and nonverbal communication cues	Identifies applications using AI in society
Apprentice	Uses data to answer a question; interprets datasets	Creates applications using perception; defines entries	Designs a simple decision tree; defines model usage	Explains types of machine learning	AI compares human performance	Determines the potential for bias; explains inclusive AI design
Practitioner	Explains data analysis (categorical or numerical)	Explains sensor limitations uses multiple sensors	Designs complex decision trees; maps effective methods	Identify bias in data; describe neural network training	Creates a chatbot; defines AI	Understands how design affects function; understands AI biases
Expert	Uses data science to solve problems	Uses complex applications with perception; creates	Defines, uses and creates search algorithms	Drives a neural network/machine learning algorithm	Defines language ambiguity; discusses consciousness	Criticizes social and ethical issues related to AI

Actua's AI teaching curriculum consist of 6 themes: data, perception, representation and reasoning, learning, natural interaction and social impacts. Each theme actually responds to one of the learning outcomes (understanding) and more than one of learning questions (investigation). In addition, the AI curriculum proposal was prepared according to the levels named "novice, apprentice, practitioner and expert" instead of an age group or grade level.

For each theme, there is an expected learning outcome and understanding which is reinforced by learning questions. In addition, it is understood that the questions in the questioning section provide a way for the trainers and a guide to provide the opportunity to deepen the discussions during the learning process.

Another non-governmental organization working on K12 AI curriculum is Kids Code Jeunesse (KCJ) in Canada. The purpose of this non-governmental organization is reaching Canadian children, girls and unqualified people to provide an access to digital skills training (KCJ, 2022). According to the information given on the website of the group, it is stated that more than 20 thousand educators and 600 thousand young people have been reached over and 1 million hours of coding courses has been done so far. KCJ's initiation is funded by both the government and private sectors such as the Canadian government, the province of Quebec, Amazon, Google and Microsoft.

According to the information given, KCJ aims to work on AI and ethics by reaching 1 million students and 50 thousand teachers in line with the UN's technology-related objectives by 2030. On the other hand, although it is stated in the web page that KCJ has a curriculum for teaching AI, this curriculum cannot be reached within this study. It is also understood that teacher trainings, information meetings and materials related to AI are made available at the request of Canadian education institutions and their staff. On the other hand, many sample activities and lesson plans are shared by Actua for an understanding of the basics of AI and machine learning.

Thus, it is found that the studies on AI teaching in Canada are carried out in 3 separate projects. One of these projects is CLC which has handled the AI teaching within a unit in the scope of computer science, and it aims to create an understanding about AI in daily life by combining data science and machine learning. The second AI teaching initiation has been handled as a separate curriculum by Actua, and it aims to teach AI more technically with subjects and applications suitable for different levels of expertise. The third and last initiation is KCJ which is similar to Actua's curriculum development study that aims to achieve a national standard for teaching AI.

As a result, AI curriculum studies in Canada are carried out at the national level with the funds and supports of private companies at K12 levels. These initiations not only include trainings and teaching activities for students but also for educators by teacher trainings workshops around Canada. AI curriculum studies are in progress around the county in order to reach out different groups of learners and teachers.

The USA

The USA has been working on AI for a long time and the studies related to AI are protected by the "National AI Initiative Law" (National AI Initiative Act, 2020). Furthermore, it is stated in the 2nd article in this law that AI studies in formal and non-formal education will be supported nationally. According to Center for Security and Emerging Technology (CSET), there are efforts to facilitate computer science curriculum in education since 2019 but the

curriculum standards change by each state although some of curriculum include AI teaching (CSET, 2021).

One initiation that provides AI curriculum and has efforts to standardize AI teaching is the AI for K-12 (AI4K12), and it is funded by National Science Foundation and Carneige Mellon University (AI4K12, 2022). This initiation aims to develop guidelines for AI teaching, prepare online resources for teaching AI, and bring AI experts, academicians, and practitioners together to establish an AI community in K12.

AI4K12's initiation is sponsored by the American AI Association (AAAI) and the Computer Science Teachers Association (CSTA). The initiation started in 2018 but curriculum development study is still in progress today. AI4K12 community consists of a management team, an advisory board, and a K12 curriculum development working group separated as K2 working group, K3-5 working group, K6-8 and K9-12 working group.

AI4K12's working group deals with the AI curriculum within five big ideas. These five ideas in the AI curriculum are known as "perception, representation and reasoning, learning, natural interaction and societal impact" (AI4K12, 2022). A curriculum draft is seen to be presented for four of the five big ideas and the study for the last big idea is still in progress.

The idea of perception, which is the first application area, is defined as "computers perceive the world using sensors". The second application area is the idea of representation and reasoning is defined as "mechanisms perceive the world, interpret it and use it to reach conclusions.". The third application area, the idea of learning, it is stated that "computers can learn from data". Natural interaction is the fourth application area, and it deals with data sources and AI agents' natural human interaction. The fifth and final idea is the social impact that deals with AI's effect on society.

India

In India, AI teaching programs at the K-12 are developed by the Central Board of Secondary Education (CBSE). CBSE is a national level educational institution for public and private schools controlled and managed by the Government of India. It is understood from the data that CBSE has developed many research and teaching programs in the field of AI. One of these studies is the study titled as "AI Integration Across Subjects for CBSE Curriculum" which is developed with the support of Intel company. This AI integration report presents lesson plans for English, Indian, Science, Maths and Social Sciences lessons, and the report is prepared in five steps (CBSE, 2022a);

1. Identifying the competency of CBSE school teachers in AI, Integration and Education in general.
2. Guiding teachers to the AI preparatory curriculum and integration process with the creation of a working group.
3. Organizing four-day comprehensive webinars on each subject in order to determine the integration sections by brainstorming.
4. Developing lesson plans related to the topics and mapping them with various AI tools and applications.

5. Verification of each lesson plan and adding a glossary for he effective use of each lesson.

In the frequently asked questions document regarding the delivery of AI course, the response to the question "At what level will AI be introduced in schools?" is that "the 8th grade is considered to be the ideal level for introducing school students to AI because children are very curious at this age. While in 8th grade this is considered a certificate course, from 9th grade it will be a regular course." (CBSE, 2022b). Information on AI teaching programs developed at different grade levels in India is given below.

6th, 7th and 8th grade curriculum

A joint AI curriculum for the grades 6,7 and 8 has been published by CBSE for the 2022-2023 academic year. The main purpose of this curriculum is to enable students to understand the world of AI by learning AI applications, games, and activities through multiple senses. A 12-hour course period is planned for the "Introduction to AI" module. The module consists of 5 subunits: "Excite, Relate, Purpose, Possibilities, AI Ethics" (CBSE, 2022c).

9th and 10th grade curriculum

An AI curriculum for grades 9 and 10 has been published by CBSE in the 2022-2023 academic year. The aim of this curriculum is to foster students' understanding of AI and its application in today's world. With this curriculum, it is aimed to develop three skills, namely "AI readiness concepts, Life skills from AI, Technical skills for AI". The 9th grade curriculum consists of four parts and nine units. The curriculum consists of 200 hours of theoretical and practical courses for two semesters (CBSE, 2022d).

The AI curriculum developed by CBSE for the 10th grades of the 2022-2023 academic year is a continuation of the 9th grade curriculum. The curriculum consists of four parts and these parts are the same as the 9th grade curriculum. The curriculum consists of 12 units as a continuation of the 9th grade units. The curriculum includes 200 hours of theoretical and practical courses for two semesters (CBSE, 2022d).

11th and 12th grade curriculum

The content of the AI curriculum prepared by CBSE for the 11th and 12th grades for the 2022-2023 academic year explains that "students will understand the effects of AI on our society and the world, and have the knowledge, skills and values to use AI in solving real problems now and in the future. will develop." (CBSE, 2022e). The 11th grade curriculum consists of four parts, as in the 9th and 10th grades, and it is a continuation of the previous curriculum. There are 15 units under these parts. The most intense content about AI is given in the 11th grade curriculum. The curriculum consists of a total of 260 hours of theoretical and practical courses for two semesters (CBSE, 2022e).

The 12th grade curriculum consists of three parts and is a continuation of the previous curriculum. There are 8 units under these sections. The curriculum consists of a total of 115 hours of theoretical and practical courses for two semesters (CBSE, 2022e).

South Korea

Starting from the 2021 fall semester in South Korea, two courses named "AI Fundamentals" and "AI Mathematics" have been added to the curriculum as elective courses in high schools across the country. It is planned to combine primary and secondary school AI curricula with pre-existing software courses (Asia Pacific Foundation of Canada, 2021). In primary and secondary school, students will learn the basic principles of AI, the use of AI and ethics (Su et al., 2022). The South Korean Ministry of Education states that it aims to implement the updated curriculum until 2025 across the country and to adopt AI in K12 schools (Asia Pacific Foundation of Canada, 2021).

An AI curriculum was developed and supported by the Ministry of Science and ICT of South Korea (Kim et al., 2021a). In this curriculum, there are 3 basic competencies such as "knowledge, skill, and attitude". Knowledge competence in the curriculum consists of 5 sub-categories: "K1: Definition and types of AI, C2: Problem solving and research, C3: Reasoning, C4: Data and machine learning, C5: Applications". For skill competence, there are 2 sub-categories called as "S1: Use of AI tools" and "S2: Computational thinking and programming". In the attitude competence, there are two sub-categories known as "A1: Social impact" and "A2: Cooperation with AI".

Austria

In Austria, the Council of Robotics and AI was established in August 2017 by the Austrian Government. The Council, established by the Ministry of Transport, Innovation and Technology, consists of academicians, industry experts and AI experts. The Council plays the role of an advisory board to advise on potential challenges and opportunities in current and future studies on AI. At the same time, another role of the council is to assist the Ministry in the development of the AI strategy (Austria AI Strategy Report, 2021).

In this context, a curriculum was developed by the Federal Ministry of Education, Science and Research in 2017. The curriculum consists of algorithms and programming, contextual problem solving, data literacy, application of AI to other fields, AI ethics, social effects of AI, AI techniques, and AI technologies subjects within "Data Science and AI" unit developed for high school students. In the curriculum, Jupyter Notebook/Lab, Python, PyCharm and Python are used as libraries to handle these subjects and unit. In addition, the curriculum focuses on natural language processing, image analysis, and big data analysis (UNESCO, 2022).

Belgium

Belgium allocated 15 million Euros for basic research, 12 Euros million for basic research, and 5 million Euros for supportive measures AI policies. (Belgium AI Strategy Report, 2022). This is the indication of the policy that the government attaches importance to

the use of AI in different fields, but the importance given to the use of AI in K12 education still remains behind when compared to other initiations regarding AI.

Although Belgium's share of education within the scope of AI policies is low compared to others, when the presence of AI in education is examined, it is generally thought that it should reach at all parties in education. For his reason, different policies, lifelong learning programs and the organization of massive open online courses are encouraged by the government. (Belgium AI Strategy Report, 2022)

According to the report called "K-12 AI Curricula; A Mapping of Government-Endorsed AI Curricula" published by UNESCO in 2022, the Wallonia-Brussels federation in Belgium has studies to develop an AI curriculum at the high school level. This high school curriculum aims to teach AI under the unit titled "IT Repository". However, these initiations are decentralized and are undertaken by educational networks. Therefore, it may differ between regions, languages, and school types (e.g. public or private) (UNESCO, 2022).

Asia Pacific (Mainland China and Hong Kong)

One of the countries that made an early attempt in many sectors in the field of AI is China. The Chinese government, which aims to increase its competencies in AI in many areas, has also made initiatives in the field of education. The findings show that that China has developed an AI curriculum for primary, secondary and high school levels (UNESCO, 2022), In this context, AI topics are included as modules in the compulsory courses called as "data and computing" and "information systems and society". In addition, a module was prepared as an elective course to foster the understanding of algorithms. This curriculum aims to explain students what AI is, how AI works and how AI is used in general. Teacher training programs take part in among the studies carried out by the Government of the People's Republic of China and the Ministry of Education on AI Technologies that support new national education initiatives and projects by the government, organizing teacher training programs for all teachers in order to support implementation and including AI subjects in these programs, allowing teachers to experience multiple devices and different platforms during their in-service trainings.

Another initiation called "Beijing Consensus on AI and Education" is carried out in partnership with UNESCO and the Ministry of Education of the People's Republic of China focused on AI education. In this initiation, UNESCO's member states and other stakeholders are made recommendation in different areas, including AI planning, education management and delivery, teaching and teacher empowerment, learning assessment, and the development of values and skills for life and work. The aim of this consensus is to appeal to a wide target audience (secondary school students, teachers, higher education students, etc.) in the field of education (UNESCO, 2022).

China's Ministry of Education adopted a new regulation on AI teaching in 2013 and appointed more than 260 experts in this field over the following four years. In this context, the development and revision of the national curriculum is managed by the Ministry of National Education (Yang, 2019).

The findings of this study show that AI curriculum studies are conducted at pre-school, primary, secondary, and high school levels in China (Su et al., 2022). One of the initiations was carried out by the Ministry of Education in 2018 in cooperation with Sensetime company. Within the scope of this cooperation, the AI textbook for K12 was developed to lay the foundations of image recognition, voice recognition, text recognition and deep learning in AI curriculum. (Sensetime, 2018; Yu et al., 2021). Also, preschool curriculum has various AI related activities (such as Expression Song, Wake-up Song, Dress-up Song, Small Mirror, Ting- a-Ling, Magazines, Take a Walk in Park, Chairs, Desk, TV, Mom's Couch, My Tiny Closet, Knife, Small Bridge, I Love Guitar, Small Sheep, Fox, Monkey, Tricycle, Red Light Green Light, Greedy Bear Bobby, Monkey goes to School) (Kim et al., 2021a). AI curriculum development for primary school education includes basic programming together with the use of interfaces such as Scracth, Ardunia, and Python. AI curriculum for secondary school includes subjects such as an introduction to AI, perception of AI, solving problems with the use of sensors, data and algorithms. Also, high school curriculum for AI focuses on AI applications, basics of AI, AI history, AI strengths and weaknesses, AI ethics, natural language processing, concept maps, problem-solving, decision-making tree etc. which are more comprehensive subjects than the previous grades.

It can be understood from the available literature that AI curriculum initiations are conducted at different grade levels in Hong Kong (Su et al., 2022). For example, Education Bureau updated the curriculum for the grades 1-6 in elementary in 2017 (Curriculum Development Council, 2017). Another finding is that there are curriculum studies for different age groups from the above-mentioned grade levels in Hong Kong (Wong et al., 2020). In this context, the curriculum developed for different age groups includes topics such as interaction with sensors, the effect of AI on daily life, making inferences, revealing the difference between AI and natural intelligence, understanding graphics and data structures, creating chatbots, creating inference algorithms, and real-world problems.

Australia

The findings of the study show that there is a preparation for the curriculum development to increase the quality of education throughout Australia. Government agencies such as the ACT Senior Secondary Studies Board, the Education, Skills and Employment Board (DESE) and the Australian Curriculum Assessment and Reporting Authority operate in this initiation across the country.

Thus, “Australian Curriculum” website which includes the curricula used up to the 10th grade titled as “F10 Curriculum” is examined together with the website of the ACT Senior Secondary Education Studies Board which is a legal institution responsible for the certification of high school education in public and private schools in the Australian capital region in detail within the scope of this study (Australian Curriculum, 2022).The finding of this research shows that there is a unit for 11^{th} and 12^{th} grades called as “Robotic Applications” that aims to foster students’ learning about AI, machine learning, the role of robots and other intelligent machines.

Germany

German Government and the Federal Ministry of Education and Research, have policies for the development of AI. In this context, competence centers and laboratories are funded to be established and to run technology related projects and programs. Also, the development of technologies for AI is supported for the automated data analysis. Similarly, the Ministry works towards the establishment of a funded network of experts responsible for coordinating and supporting the transition to the digital economy in order to put Germany in a leading position in the industry 4.0 ecosystem (AI International Future Labs, 2022).

In the report published (K-12 AI Curricula; A Mapping of Government-Endorsed AI Curricula) by UNESCO in 2022 it is seen that Germany is currently continuing its efforts to develop curriculum for AI education. The Permanent Conference of the Ministry of Education and Cultural Affairs presented "Defining and Formulating Algorithms" unit for the primary, secondary, and high school curricula.

It is clear from OECD's report that there are 32 research reports on AI studies throughout Germany, However, these reports are generally about AI in transportation, environment, industry, economy, etc. Thus, it is found that there is no regulation of AI education in K12 and there is not any curriculum development preparation regarding AI teaching in K12 (OECD.AI, 2021a).

Japan

In 2017, "AI Technology Strategy" document was published by the AI Technology Strategy Council in Japan (Strategic Council for AI Technology, 2017). Within the scope of this strategy document, it is emphasized that AI can provide significant benefits in various sectors such as health, tourism, and information security in the country (Strategic Council for AI Technology, 2017).

Although Japan is a leading country in the development of technologies in the field of AI, there are deficiencies in its AI education policy (Eguchi et al., 2021). At this point, a project was initiated to develop an AI curriculum at the K-12 level in Japan. The AI curriculum to be developed within the scope of the project will be based on the "Five Big Ideas" of AI4K12 of the USA (Su et al., 2022). Apart from this project, it is understood from the literature that there is no other AI curriculum initiation in Japan regarding K12 education.

Russia

In the research conducted within the scope of this study, it is revealed that Russia does not have AI curriculum. On the other hand, the President of Russia stated that the countries moving towards the development of AI technologies and advancing in this technology will be in the leading position among other countries in the future (Vincent, 2017). Immediately after this announcement in 2018, the first official AI strategy document for national AI studies, prepared by the Russian Ministry of Defense, the Ministry of National Education and Science, and the Russian Academy of Sciences, was presented (Russian Federation Ministry of Defense, 2018). It is very clear from one of the items regarding Russia's AI strategy (setting a governmental system for teaching AI) that it will also focus on artificial teaching soon (Petrella

et al., 2021). However, this is the only information found regarding AI teaching and curriculum development.

Turkey

It is found in this study that Turkey does not have an AI curriculum. On the other hand, it is seen that studies are carried out regarding AI in Turkey. The most comprehensive of these studies is the "National AI Strategy", which was prepared in 2021 with the cooperation of the Ministry of Industry and Technology and the Presidency's Digital Transformation Office, within the scope of the National Technology Movement, and it targets the studies between 2021 and 2025 (UYZS, 2021).

While aiming to increase the quality of the studies on AI and to contribute to global studies, it is seen that the following 6 strategic priorities are discussed in the strategy document (UYZS, 2021);

1. Educating AI Experts and Increasing Employment in AI field
2. Supporting Research, Entrepreneurship and Innovation
3. Expanding Access to Quality Data and Technical Infrastructure
4. Making Arrangement to Accelerate Socio-economic Adjustment
5. Strengthening International Cooperation
6. Accelerating Structural and Labor Transformation

Thus, the strategic priority of "Educating AI Experts and Increasing Employment in AI field" includes studies such as strengthening the curriculum on AI, algorithmic thinking, and ethics, developing digital content, and encouraging teachers with in-service trainings to implement this curriculum (UYZS, p. 66, 2021). In this context, the Ministry of National Education (MEB) states that studies have started on the development of a curriculum and the inclusion of AI technologies in education services in cooperation with Istanbul Technical University on AI teaching (MEB, 2019). Afterwards, the Ministry introduced "MEB Assistant" that provides guiding services for students and "EBA Academic Support System (ADES)" that provides academic assistance (MEB, 2020).

A curriculum for AI teaching has not yet been specified by Turkish Ministry of Education, but among National Technology Movement Initiation aims, there are "Deneyap Türkiye" trainings aiming to contribute to the development of young people in the field of technology to lay the foundation of AI and educate young people on the use of AI in different fields. (Deneyap Türkiye, 2022).

Saudi Arabia

This study reveals that Saudi Arabia does not have a K12 AI curriculum However, according to the information obtained from the OECD report, Saudi Arabian Data and AI Center (NCAI) was established in 2019 (OECD, AI, 2022b). The AI policy of the Center includes the areas of "competition, digital economy, business, innovation, investment, science, technology, welfare and education" (OECD, AI, 2022b). Although it is not stated in any documents, it is thought that this center will focus on education too.

France

In the OECD's report and the databases examined within the scope of this study, it is understood that France conducts studies on AI in many sectors with no reference to teaching AI at K12 levels (OECD.AI, 2022b). Looking at the studies on AI in France, a report titled "For A Meaningful AI" was published in 2018 by the famous mathematician and member of the French Parliament, Cédric Villani, and other members of the Villani Mission (Villani, Bonnet & Rondepierre, 2018). The aim of this report is to make France one of the developed countries in the field of AI in research, human skills and ethics (OECD.AI, 2022c). Within the scope of the report, subjects such as the relationship between AI and economy, the ethics of AI, and the benefits of AI in employment are discussed. However, there is no section in the report that deals specifically with AI teaching in K12 education.

Italy

In this study, it is found out that there is not an AI curriculum developed by Italy. However, it is also seen that there are some studies in various fields on AI in the country. One of these studies is found in an official report titled as "AI at the Service of the Citizen" by the Agency for Digital Italy in 2018 (Agency for Digital Italy, 2018). In this report, the difficulties that can be experienced in the integration of AI into government services, the issue of AI ethics, the most effective evaluation of qualified employees and the role of data are mentioned. At the end of the report, various suggestions for the application of AI in different fields are presented but there is no section in this report that deals specifically with AI in K12 education.

The most important development in the field of AI in Italy is the "Strategic Program on AI" report which was published in November 2021, and it covers the years between 2022-2024. Within the scope of this report, it is seen that there are three aims. These aims are strengthening and promoting the capabilities and competencies that will enable the AI-powered economy, expanding the funding of advanced research in the field of AI, ensuring the adoption of AI and its applications both in public administration and in the Italian economy in general (Italian Government, 2021). In addition, it is pointed out in the report that 11 sectors should be given priority in the field of AI, and the education system is ranked second among these sectors although there is not a theoretical or practical study regarding AI teaching in K12 education.

United Kingdom

Within the scope of this study, it is found out that the UK does not have an AI curriculum for K12 Education. However, a report was published regarding AI by the United Kingdom House of Lords Provisional Commission in 2018 called as "AI in the UK: ready, willing and able?". The developments in the field of AI are discussed in the context of economic, ethical and social impact, and a number of recommendations are made for the government to consider AI developments (House of Lords, 2018). In this report, it is explained that AI has an indisputable importance in today's world, and it should take its place in education system.

Another study in the UK is published in 2018 which is called as "AI Sector Deal". The purpose of this report is to make the UK a global leader in AI. To this end, the policies developed in the report are built on five areas. These areas are ideas, people, infrastructure, business environment

and location (HM Government, 2018). However, there is no section that deals specifically with AI education K12 in this report.

Another report was published in September in 2021 (known as National AI Strategy) but it also does not have a direct reference to education sector. The strategy report includes issues such as;

- A plan to make the UK a superpower in AI,
- National AI strategies of the United Kingdom,
- Investing in and planning for the long-term needs of the AI ecosystem to become a superpower in science and AI,
- Steps to be taken for AI to benefit all sectors and regions,
- Initiation to and collaborations to be established to effectively manage AI (HM Government, 2021).

Mexico

Mexico does not have an AI teaching curriculum, but it also published a report titled as "Towards an AI Strategy In Mexico: Harnessing the AI Revolution" by Oxford Insights and C Minds in June 2018. The content of the report consists of the current situation of the AI in Mexico and related AI policies. The report stated that it aims to make Mexico one of the top ten countries including United Kingdom, Canada, China, UAE, Singapore, South Korea, France and Japan (Oxford Insights & C Minds, 2018). However, there is no section in this report that deals with AI education in K12.

South Africa

With regards to South Africa, it is seen that the country does not have an AI curriculum. However, it is understood from the documents examined that a speech was made by President Khumbudzo Ntshavheni in November 2021 that explains the importance of AI (South African Government, 2021). In this speech, it is stated that AI is considered as one of the main focus of the South African digital economic development strategies. In the statements of President Khumbudzo Ntshavheni, it is emphasized that there is a race between countries in the field of AI and South Africa should not be left behind in this race without any reference to AI education in K12.

Indonesia

In Indonesia, there is no AI curriculum, and it is seen in the available literature that there is a very limited study regarding AI teaching in Indonesia. It is found that the country published "National AI Report" covering the years between 2020-2045 (OECD.AI, 2022d). According to the strategy report, Indonesia aims to realize reforms in many sectors such as education, health, food and logistics. Indonesian Minister of Education, Culture, Research and Technology Nadiem Makarim stated that science is developing globally, and that AI will have a great impact on the business world in the future (Open Gov Asia, 2021). However, there is no direct reference to AI in K12.

Argentina

Regarding Argentina's AI studies, 11 research reports are presented in OECD's report (OECD.AI, 2022e). On the other hand, it is observed that these reports focus on the use of AI in the fields of health, public, security, digital data processing, 4.0 technologies, education, information technologies and the private sector.

When the research report on education (EDUC.AR, 2021) published by the OECD is examined, it is seen that this report was launched in 2018 under the responsibility of the Argentine Ministry of Education. It is understood from the report that AI education in the country aims at educating individuals in AI by starting AI education in the early ages. This report sees higher education institutions, undergraduate, graduate, secondary education, doctoral students and teachers as direct beneficiaries. Yet, there is no direct curriculum development initiation found in the available literature.

Brazil

The findings of the study show that there is no AI related curriculum for K12 levels in Brazil. However, there are 10 reports on AI strategy and policy initiatives conducted in Brazil on OECD' web page (OECD.AI, 2022f). It is also understood from the findings that these studies and initiations published are about the use of AI and AI strategies in public sector apart from education.

Discussion and Results

This part of the study consists of; countries' AI teaching objectives, teacher training, units, subjects and learning outcomes, tools, resources, and programming languages, age – class levels, AI teaching initiations. A brief information is also provided in Appendix 2.

AI Teaching Objectives

It is understood from the AI strategies of the countries covered in this study that they aim to benefit from the opportunities that AI can provide in many different sectors. In the education sector, it is seen that the countries carrying out AI curriculum studies have various objectives related to AI teaching.

In this context, it is understood that Canada, which has more than one curriculum initiation for K12, plans to provide technology education to people living in Canada by considering the AI curriculum within a national framework (CLC, 2022). At the same time, another study conducted in Canada, Actua, aims to increase the basic skills and knowledge of high school students about AI and machine learning, and to have students learn about how AI will affect professions in the future (Actua, 2020). Similarly, with the Kids Code Jeunesse AI curriculum initiative, teaching digital skills to children, girls and disadvantaged groups are among the objectives of teaching AI in Canada (KCJ, 2022).

The AI curriculum of the USA, on the other hand, is handled on the basis of classes at the K12 level, different from the levels defined levels specified in Canada's curriculum. In this context, the initiation of The USA is handled under the themes called as "five big ideas" and the curriculum aims to deal with AI teaching within a national standard, including all K12 students.

In addition, creating online resources for AI teaching, planning teacher training, and bringing together academics, experts, and practitioners to create a K12 community are among the goals of this AI curriculum initiation.

With AI education offered at different levels, India, which has AI curriculum initiation, enables students to learn the opportunities that AI will offer to individuals and society in order to create an infrastructure on AI applications, and to use AI effectively in the solutions of future problems (CBSE, 2022a).

Different from Canada and the USA, Asia Pacific's (China and Hong Kong) AI curriculum initiations aim to teach students the use of AI and its potential contributions to society by introducing AI to the students by targeting studies on the applicability of AI in society (Sensetime, 2018; Yu et al., 2021). Thus, it is thought that keeping up with the changing situations of the society and meeting the needs of individuals can be met with the AI curriculum (Curriculum Development Council, 2020).

It is seen that Australia aims to investigate the role of robots and other smart machines equipped with AI technologies in society by adding AI subject under the robotic applications unit of the 11th and 12th grade levels. This situation is very similar to Canada's initiation which also takes AI teaching subjects under the existing K12 curriculum of computer sciences.

Thus, it is understood that countries aim to benefit from the opportunities that AI will offer in the future by developing an understanding of AI and increasing digital skills of students by systematically incorporating AI teaching into their curricula or developing curricula specific to AI for K12.

Teacher training

The studies on the development of AI teaching curricula and their implementation in schools have intensified in recent years, therefore there is a lack of teachers who have sufficient theoretical knowledge and practical skills on this subject. For this reason, teacher training for teaching AI teaching has become a necessity for the countries.

The USA's "5 Big Ideas" curriculum, which is one of the curricula of AI for K12, has plans for teacher training. However, the finding shows that this training is limited to providing materials to teachers on AI, preparation of videos, and related software for AI teaching (AI4K12, 2022). In Austria, the teacher education strategy is designed to support teachers' pedagogical development. (UNESCO, 2022). At this point, AI teacher trainings are provided during pre-service teacher education.

To support the teaching of AI in schools in China, teachers of all subjects are provided "National Level Teacher Training" program (part of the program focused on Information Science and Technology with AI). Teachers are required to attend the program every three years. Within the scope of the program, both school administrations and teachers examine the types of technology to be used in the classroom. During this training, teachers are shown different devices, platforms, and teaching technologies. However, the types of technologies to be used in the classroom for AI teaching is not explicitly stated (UNESCO, 2022). Taking this

situation into consideration, it can be deduced that teachers are provided with flexibility for the technologies to be integrated into their lessons.

Although limited information is available on teacher education in South Korea regarding AI teaching. according to Kim et al. (2021b), the primary school level AI curriculum for South Korea is based on AI4K12's AI initiation called as "5 Big Idea ideas". For this reason, activities for teacher training in South Korea are similar to the USA's. When the AI curriculum of South Korea is examined, it is seen that teacher guides and course plans for AI teaching are presented for teachers in order them to deliver the content effectively. The prepared materials are made available to teachers through in-service trainings.

When the Canadian AI curriculum initiations are examined, it can be understood that various trainings and workshops are planned for teachers. In this respect, unlike Canada and Australia, a teacher training policy is adapted similar to the USA and South Korea. Thus, Canada aims to make 50 thousand teachers competent about AI with teacher training programs and workshops to be held by 2030 (KCJ, 2022).

Moreover, it is seen that India also carries out a comprehensive preparation on the training of teachers who will provide AI teaching. Considering the AI curriculum of the 9th and 10th grades of the 2021-2022 academic year in India, the qualifications, minimum qualifications, and age limit of the teachers who will teach this course has already been defined. For instance, teachers must have a Computer Science/Information Technology degree or higher in order to teach AI and teachers must have at least one year of work experience, be able to communicate in the local language and English and have knowledge of tools and materials. Interestingly, the age limit of teachers is required to be between 18 and 37 years old (CBSE, 2022d).

In India, different from other countries, teachers are very active in the stages of the integration of AI into education and curriculum development activities as well as teacher education in AI (CBSE, 2022b). Therefore, it is understood that the role of the teacher is very important for the AI curriculum in the country.

When we look at the AI teaching programs of the countries, it is seen that in-service teacher trainings and supportive materials are prepared for teachers in some countries such as the USA, Canada, and South Korea. These materials consist of teacher's guidebook, supporting videos, presentations, and informative documents for AI activities. In addition, introductory trainings are organized for teachers about the tools, technologies, and environments to be used in the classroom during AI teaching. It is also seen that countries such as Australia and India have studies to make teacher education more comprehensive and systematic, starting in pre-service education while in in China teacher trainings are repeated at certain intervals in-service.

Content and Learning Outcomes

AI4K12 curriculum of the USA consists of 5 subjects called as "Perception, Representation and Reasoning, Learning, Natural Interaction, Social Impact" (AI4K12, 2022). These subjects are named as "5 big ideas" and the learning outcomes of the curriculum are studied under these ideas.

The Actua's AI curriculum in Canada is also based on AI4K12's curriculum. For this reason, when the contents of this curriculum are examined, it is seen that it is similar to the USA's AI curriculum in terms of subjects and learning outcomes. The curriculum consists of 6 themes: "Data, Perception, Representation and Reasoning, Learning, Natural Interaction, Social Impacts". The learning outcomes are determined considering four different learning levels from novice to expert (Actua, 2020). Within the scope of the curriculum, there are learning outcomes related to data types, use of data in AI models, machine models, machine perception, neural networks, and ethics.

The AI curriculum developed for South Korea is based on the AI4K12's Five Big Ideas as in Canada's Actua curriculum. The curriculum focuses on providing students AI literacy through project-based learning and problem solving. It is seen that the activities suggested consists of examples that are related to daily life. In the curriculum, it is suggested that the evaluation process should be done with students' peer interaction, presentation, and discussion. The subjects in the curriculum are "(1) Introduction to AI, (2) Traditional Approaches of AI - Search and Reasoning, (3) Face Detection, (4) Speech Recognition, (5) Machine Translation, (6) Image Classification, (7) Text Classification is (8) Self-Driving Cars".

Within the scope of another AI curriculum in Canada, there are 5 units within the computer science course, known as "programming, computing and networks, data, technology, society and design". These units include subjects such as "algorithm, data structures, hardware-software, cyber security, data storage, data visualization, AI, machine learning". These subjects are determined for five different learner levels from beginners to advanced learners (K12csframework, 2020).

Looking at the Indian curriculum, AI is taught from grade 6 to grade 12 for the 2022-2023 academic year. In general, the aim of the curriculum is for the use of AI in daily life rather than technical education as in Canada and the USA. For the 6th, 7th and 8th grades, the unit is defined as "Introduction to AI". The sub-units are determined as "Excite, Relate, Purpose, Possibilities, AI Ethics". Among the learning outcomes are defining AI and explaining its place in daily life, human machine interaction applications, natural language processing, AI literacy skills, AI and ethics.

In India, it is seen that the basic subjects from the 9th to the 12th grade progress in a way to complement each other. For the first part of the 9th grade curriculum, the units are presented as "Communication Skills-1, Self-Management Skills-1, Information and Communication Technology Skills-1, Entrepreneurial Skills-1, Green Skills-1". The 12th grade curriculum units are "Communication Skills-4, Self-Management Skills-4, Information and Communication Technology Skills-4, Entrepreneurial Skills-4, Green Skills-4".

Units for 9th graders consist of "Introduction to AI, AI Project Cycle, Neural Network, Introduction to Python". Units for 10th graders are presented as "Introduction to AI, AI Project Cycle, Advance Python, Data Sciences, Computer Vision, Natural Language Processing". In addition, the units for 11th grade are "Introduction to AI, AI Applications & Methodologies, Math for AI, AI Values (Ethical Decision Making), Introduction to Storytelling, Critical & Creative Thinking, Data Analysis (Computational Thinking), Regression, Classification &

Clustering, AI Values". Units for 12th graders also consist of "Capstone Project, Model lifecycle, Storytelling through data".

In Indian AI curriculum, it is seen that foundation of the AI curriculum is built in the 6th, 7th and 8th grades, and advanced content is presented to the students in the 9th grade, and the most intense content is given in the 11th grade.

For the primary school level, the learning outcome is related to "basic programming with Scratch and Python, perceiving the environment with Arduino, being familiar with various robots". Also, secondary school level AI curriculum includes units like "introduction to AI, AI perceptions, use of sensors, solving problems through data and algorithms". In addition, subjects for high school students consist of "AI, AI Applications, AI Fundamentals, AI History, Strong AI Weak AI, AI Ethics, Introduction to NLP, AI Language, Parts of Speech, Natural Language Processing, Word Vectors, Syntax Parsing, Information Extraction, Knowledge Map, Problem Solving, Logic Inference, Expanding Logic Inference, Recognition Framework, Decision Tree Training, Search Engines".

Examining the Chinese AI curriculum, it is seen that the subjects are increasingly intensifying according to the education level. High school students are the learner level with the most content for the AI course. Similar to India, Canada, South Korea, the Chinese AI curriculum aims to guide students to understand what AI is, how it works, and AI takes place in social life.

Hong Kong's AI curriculum has been developed with the units of "perception, social impact, natural interaction, representation and reasoning, machine learning, deep learning" similar to countries such as Canada, the USA and South Korea. The subjects consist of "interaction with sensors, the effect of AI on daily life, inference processes, creating and modifying applications based on perception, basic concepts related to coding and applications".

The Australian AI curriculum has different contents than other countries. The curriculum is developed for 11th and 12th grade students, preparing for higher education, and students with intellectual disability. "Robotic Applications" unit in this curriculum focuses on AI and machine learning.

In Austria, the weight of the subjects is expressed in percentages in the AI curriculum. Under the unit of "Data Science and AI", the curriculum includes subjects such as "Algorithms and programming (25%), Contextual problem solving (10%), Data literacy (15%), Application of AI to other fields (15%), AI Ethics (10%), Social Effects of AI (10%), AI techniques (5%), AI technologies (5%), AI Development (5%)".

When the AI curricula of the countries are examined, it is seen that the subjects and learning outcomes of the USA, Canada, South Korea, India, China and Hong Kong curricula are similar to each other. The main purpose of the curriculum developed for these countries is to enable students to understand the place of AI in daily life. It is seen that the curricula in Australia and Austria are planned differently compared to these countries. It is seen that the AI curriculum in Australia concentrates mainly on the field of robotics. In Austria, the subjects are planned to cover a certain percentage of the unit as stated above.

Tools, resources, and programming languages

Considering the Canadian AI curriculum, “Raspberry Pi, Voiceflow, Scratch, Little Robot Friends, Glitch, Arduino, CoSpaces, Trinket, Pixlr, Canva, Piskel, Soundtrap, TinkerCad, Micro:bit, SketchUp, Lynx. , ScratchJr, BeeBot, Repl.it, Makecode, Art:bit, The Algorithm Literacy Project” are used as tools and programming langues in the curriculum (K12 Computer Science Framework, 2022). Similar to Canada, programming languages and tools such as "Scratch, Python, Arduino" are used in the Chinese AI curriculum.

In the Austrian curriculum, programming languages and tools such as “Scikit-learn, Keras, Tensorflow, Jupyter Notebook/Lab, Python, PyCharm” are used for AI teaching.

When Indian AI curriculum is examined, the recommended resources and tools to be used are listed as “Desktop Computer / Laptop / Tablet, Webcam, Scanner, Projector & Screen, Printer, Hub/switch, Internet”. The programming software is specified as “Microsoft Office Applications, Anaconda Navigator, Web Browser”. Python programming language is used within the scope of this curriculum similar to Austria. Regarding the other countries’ AI curriculum for K12, there is no information found on the tools, resources and programming languages used.

Age – class levels

Examining the strategies or curricula developed by the countries in this study, it is concluded that most of the studies carried out are developed for different levels of K12 (at primary, secondary or high school levels) in general. However, it is seen that three separate studies are conducted by different initiatives for the general K12 levels in Canada including, girls and the disadvantaged group of learners. When the studies of China, The USA, India, South Korea, Japan, Hong Kong, Germany, and Argentina in the field of AI are examined, it is seen that the AI curriculum addresses the general levels of K12 instead of focusing each grade level separately.

In Austria, the curriculum is only for the high school level students, while the AI studies in Belgium cover a wider student group starting from pre-school to higher education levels. Specifically, in Austria, the curriculum targets 11th and 12th grade students who are preparing for higher education and the students who have mental disability.

After the analysis of the countries which do not have an AI curriculum but has at least a strategy document like Turkey, Russia, Saudi Arabia, France, Italy, the United Kingdom and Mexico, it is understood that there is no specified age groups or grade levels for the prospective AI curriculum development initiations. Finally, when the studies carried out in the field of AI in South Africa, Indonesia and Brazil are examined, no concrete documents (curriculum, strategy, etc.) are found.

Overall, it is seen that many countries carry out their curriculum development studies in a way to cover K12 grades. Countries that have not yet started their curriculum development initiations have generally developed their country strategies, and in this context, they have determined roadmaps on the importance and roles of AI in educational environments.

AI teaching initiations

In this part of the study, the strategies and/or curricula developed by the countries are examined with regards to AI teaching. The findings show that some countries have developed curricula for different levels, and some have developed strategies related to AI.

When the initiations in the field of education in India are examined, it is concluded that more than one AI teaching program has been developed by the government in collaboration with Intel company. Within the scope of this cooperation, the curriculum titled "AI Integration Across Subjects for CBSE Curriculum" is being developed for AI teaching.

When the studies conducted in China on the use of AI in the field of education are examined, it is found that the curriculum for primary, secondary, and high school levels has been developed in cooperation with state and private institutions, similar to the initiation of India. Another curriculum development initiation started out in China is the study called "Beijing Consensus on AI and Education" in partnership with UNESCO and the Ministry of Education of the People's Republic of China.

In Hong Kong, the AI curriculum for different grade levels have been developed by government institutions similar to those of India and China. In addition, there are the efforts to update the existing curriculum for AI teaching in the country.

When the initiation of AI teaching in Austria is examined, it is seen that "Robotics and AI Council" is established and accordingly, a curriculum is developed by government institutions as in Hong Kong.

In Germany, it is found that there is a curriculum development for AI teaching similar to India, China, Hong Kong and Austria, but unlike these countries, these studies are still progress. Examining the initiations carried out by state institutions, it is seen that AI curriculum will have an effect to whole education system holistically.

When the studies conducted in Belgium on the use of AI in the field of education are examined, it is concluded that studies are carried out to develop an AI curriculum at high school level. The curriculum development study is still in progress, similar to the initiation of Germany. In addition, various policies are being developed to cover all education levels in order to support AI developments in the regional states.

In Canada, there are three different attempts to integrated AI in education. These attempts are "Learning for the Digital World: A Pan-Canadian K12 Computer Science Education Framework", "Actua" and "Kids Code Jeunesse (KCJ)" which are all supported by both state institutions and private sectors.

When The USA's AI initiations are examined, it can be concluded that there are different AI curriculum developments in cooperation with the state and non-governmental organizations, similar to the attempts in Canada. These studies differ depending on the states' education systems and their policies.

When the studies carried out on the use of AI in education in Turkey are examined, there are three different initiations at the state level. These initiations are “National AI Strategy”, the second is an ongoing study to in cooperation with the Ministry of National Education (MEB) and Istanbul Technical University, and the third one is the “Deneyap Turkey” trainings which includes AI teaching and learning activities partially.

In Russia, it is seen that there is no curriculum development initiation for AI teaching. However, the first official AI strategy proposal is presented as a result of the work of the Russian Ministry of Defense, the Russian Ministry of Education and Science, and the Russian Academy of Sciences. When the studies conducted in Saudi Arabia on the use of AI in the field of education are examined, it is seen that the government established “Data and AI Center (NCAI)” for AI studies, and there is a strategy focusing on AI in general similar to the AI strategy of Russia. The inhiation of Italy regarding to AI is closely similar to that of Russia and Saudi Arabia. It is seen that they also published their AI strategy which does not focus on AI teaching directly.

United Kingdom does not have an AI curriculum. However, two research reports have been published on the subject throughout the country. These are called as “AI in the UK: ready, willing and able?” and “AI Sector Deal” published by the UK House of Lords Interim Commission.

In Mexico, there is no curriculum development initiation. However, similar to the research reports published by the government in the United Kingdom, a research report titled as “Towards an AI Strategy in Mexico: Harnessing The AI Revolution” has been published by private sector companies. In Japan, it is understood that AI curriculum development has been started, and this study is based on The USA’s AI curriculum known as AI4K12. In Indonesia, it is seen that there is no AI curriculum developed. However, a report called as “AI National Strategy” is published covering the initiations of AI until 2045.

When the studies on the use of AI in the field of education in Australia are examined, it is concluded that the existing curricula are updated, and AI technologies are included in curricula in order to increase the quality of education. In addition, there are updates take place in the existing curricula of high schools in the capital region in order to offer different opportunities to students by a legal institution responsible for the certification of high school education.

When the studies conducted in South Korea on the use of AI in the field of education are examined, it is seen that a new curriculum has been developed as well as updates in the existing curriculum similar to Australia. Accordingly, it is concluded that two courses related to AI are added to the curriculum as elective courses in high schools across the country. It is planned to combine primary and secondary school AI curricula with pre-existing software courses (Asia Pacific Foundation of Canada, 2021).

Finally, the initiations regarding the use of AI in education in France, Argentina, South Africa and Brazil are examined, and it is found that these countries do not have either curriculum development attempts or strategy reports.

As a result, it is concluded that most of the countries (including Turkey, Russia, Saudi Arabia, Italy, United Kingdom, Mexico, Indonesia, France, Argentina, South Africa and Brazil) have

not yet taken a concrete step in the development of AI curriculum for K12 and have carried out some studies published as strategy or research reports. In addition, the AI education has started at K12 levels in the countries such as India, China, Hong Kong, Austria, Germany, Australia, South Korea and Belgium and these countries has ongoing AI curriculum development studies. It is also understood that countries carrying out studies on AI curriculum development initiations receive support from different institutions and organizations. While some countries manage the process only with the help of government institutions during the development of curriculum, some countries cooperate with private companies and non-governmental organizations. These different strategies followed are directly related to the management structures and the policies of the countries, their level of developments, and most importantly, their perspectives on the subject. It is seen that in the countries with which private sector cooperation is made, the scope of the curriculum is tried to be as wide as possible including students from different age groups. In the initiations carried out by the state or the government itself, it is seen that a certain education level is primarily targeted for AI teaching and curriculum development studies.

Suggestions

Different purposes are put forward by different sectors regarding artificial intelligence. As the core of this study is to examine AI curriculum developments and initiations, it is suggested that the purpose of teaching artificial intelligences at K12 levels should be creating an awareness and understanding of artificial intelligence itself and its potential opportunities. By this means, the society will have individuals having sufficient knowledge of artificial intelligence in order to catch up with technologies and products of artificial intelligence as implied in India's artificial intelligence curriculum study (CBSE, 2022a). The effective continuation of artificial intelligence teaching is closely related to teacher education and training. For this reason, training of teachers should be included in the pre-service education system of teachers, as suggested in Australian artificial intelligence curriculum development study, and the training of in-service teachers should be done periodically as in Canada. The trainings can include hands-on workshops and seminars for teachers who will be teaching artificial intelligence at K12 levels. Instead, the qualifications of artificial intelligence teachers can be determined at first, and then, these teachers can be trained at certain periods with supporting materials (CBSE, 2022d).

It is seen that countries such as Canada and South Korea benefit from AI4K12 artificial intelligence curriculum as the starting point for determining units, subjects and learning outcome in their artificial intelligence curriculum development initiations (AI4K12, 2022). However, it should be known that the last big idea of AI4K12 called as "societal impact" is still under progress, but it does not mean that potential countries may not be able to originate their own units, subjects and learning outcomes of artificial intelligence teaching by using AI4K12's available data. Although it is seen that there has been a limited information about the tools, resources and programming languages suitable the curriculum development studies so far, Canada's study for this can be taken as an example at suggest some tools, resources and programming languages such as "Raspberry Pi, Voiceflow, Scratch, Little Robot Friends, Glitch, Arduino, CoSpaces, Trinket, Pixlr, Canva, Piskel, Soundtrap, TinkerCad, Micro:bit, SketchUp, Lynx, Scratch Jr, BeeBot, Repl.it, Makecode, Art:bit, The Algorithm Literacy Project" (K12 Computer Science Framework, 2022).

Countries that plan to teach artificial intelligence can include all levels of K12 in their curriculum with appropriate units, subjects and learning outcomes without any age or classroom level restrictions according to existing education systems. On the other hand, if a country wants to prepare or implement artificial intelligence curriculum on a specific age group or class level, Australia's artificial intelligence curriculum can be taken as an example as it focuses on specific K12 levels such as 11th and 12th grades (Australian Curriculum, 2022). It is seen that the countries like Canada and America have progressed in artificial intelligence curriculum and these countries cooperate with private sector institutions like Amazon, Google and Microsoft which provides both funding and trainings for technology education. In this sense, the initiations and movements of countries are made stronger with the private sector collaboration as in another government – private sector collaboration in India. Therefore, it is thought that it will be more effective for countries that plan to develop or implement artificial intelligence curriculum to act with private sector organizations to support their movements and provide trainings and material for teachers and learners.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

Actua. (2020). *Actua's Artificial Intelligence (AI) Education Handbook.* Retrieved March 25, 2022 from https://www.actua.ca/wp-content/uploads/2020/01/Actua-AI_Handbook.pdf

Agency for Digital Italy. (2018). Retrieved May 21, 2022 from https://ai-white-paper.readthedocs.io/en/latest/

AI International Future Labs. (2022). Retrieved May 20, from https://www.bmbf.de/bmbf/en/international-affairs/worldwide-networking/internationalization-strategy/international-future-labs-for-artificial-intelligence/international-future-labs-for-artificial-intelligence.html

AI4K12. (2022). *Working Group and Advisory Board Members,* Retrieved April 20, 2022 from https://ai4k12.org/working-group-and-advisory-board-members

Alomari, M & Jabr, M. (2020). The effect of the use of an educational software based on the strategy of artificial intelligence on students' achievement and their attitudes towards it. *Management Science Letters, 10*(13), 2951-2960.

Asia Pacific Foundation of Canada. (2021). *Talent For The Future: AI Education for K-12 in Canada and South Korea.* Retrieved May 24, 2022 from https://www.asiapacific.ca/sites/default/files/publication-pdf/AI%20K-12%20Education%20Report_FINAL.pdf

Australian Curriculum (n.d). Retrieved May 28, 2022 from v9.australiancurriculum.edu.au

Austria AI Strategy Report (n.d). Retrieved March 30, 2022 from https://ai-watch.ec.europa.eu/countries/austria/austria-ai-strategy-report_en

Belgium AI Strategy Report (n.d). Retrieved March 17, 2022 from https://ai-watch.ec.europa.eu/countries/belgium/belgium-ai-strategy-report_en

Burgsteiner, H., Kandlhofer, M., & Steinbauer, G. (2016). IRobot: Teaching the Basics of Artificial Intelligence in High Schools. *Proceedings of the AAAI Conference on Artificial Intelligence*, *30*(1). Retrieved April 25, 2022 from https://ojs.aaai.org/index.php/AAAI/article/view/9864

CBSE. (2022a). *Artificial Intelligence Integration Across Subjects For CBSE Curriculum.* Retrieved May 21, 2022 from http://cbseacademic.nic.in/web_material/Curriculum20/AI_Integration_Manual.pdf

CBSE. (2022b). *Frequently Asked Questions.* Retrieved May 21, 2022 from https://cbseacademic.nic.in/web_material/Curriculum20/Class_IX/417-FAQ.pdf

CBSE. (2022c). *Modules for Middle School (class VI/VII/VIII).* Retrieved May 21, 2022 from https://cbseacademic.nic.in/web_material/Curriculum21/middleLevel-CourseOutline.pdf

CBSE. (2022d). Retrieved May 21, 2022 from https://cbseacademic.nic.in/web_material/Curriculum22/Skill/417-AI_2020-21.pdf

CBSE. (2022e). Retrieved May 21, 2022 from https://cbseacademic.nic.in/web_material/Curriculum22/SrSec/843-ARTIFICIAL_INTELLIGENCE_XI_XII.pdf

Center for Data Innovation. (2016). Retrieved April 12, 2022 from https://euagenda.eu/upload/publications/untitled-53560-ea.pdf

Chiu, T. K., & Chai, C. S. (2020). Sustainable curriculum planning for artificial intelligence education: A self-determination theory perspective. *Sustainability*, *12*(14), 5568.

Ciolacu, M. I., Binder, L., & Popp, H. (2019, October). Enabling IoT in Education 4.0 with biosensors from wearables and artificial intelligence. In *2019 IEEE 25th international symposium for design and technology in electronic packaging (SIITME)* (pp. 17-24). IEEE.

CLC (n.d). Retrieved March 30, 2022 from https://www.canadalearningcode.ca/about-us/

Creswell, J. W. (2007). *Qualitative inquiry and research design.* Thousand Oaks: Sage.

CSET. (2021). *AI Education in China and the United States; A Comparative Assessment.* Retrieved April 20, 2022 from: https://cset.georgetown.edu/publication/ai-education-in-china-and-the-united-states/

CSTA. (2017). *CSTA K12 computer science standards.* Retrieved from https://portal.ct.gov/-/media/SDE/CTE/CSTA-K12-Computer-Science-Standards-Revised-2017.pdf.

Curriculum Development Council. (2017). *Technology education: Key learning area curriculum guide (primary 1-secondary 6).* Education Bureau of Hong Kong. Retrieved from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/technology-edu/curriculum-doc/TE_KLACG_Eng_5_Dec_2017_r2.pdf.

Curriculum Development Council. (2020). *Computational thinking – coding education: Supplement to the primary curriculum (primary 1-primary 6).* Education Bureau of Hong Kong. https://www.edb.gov.hk/attachment/en/curriculum-development/kla/technology-edu/curriculum-doc/CT_Supplement_Eng%20_2020.pdf.

Deneyap Türkiye, (2022). Retrieved May 25, 2022 from https://deneyapturkiye.org/egitim-YAPAY-ZEKA-19.html

EDUC.AR (2021) Retrieved May 19, 2022 from https://oecd.ai/en/dashboards/policy-initiatives/http:%2F%2Faipo.oecd.org%2F2021-data-policyInitiatives-26963

Eguchi, A., Okada, H. & Muto, Y. Contextualizing AI Education for K-12 Students to Enhance Their Learning of AI Literacy Through Culturally Responsive Approaches. *Künstl Intell 35*, 153–161 (2021). https://doi.org/10.1007/s13218-021-00737-3

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education. 7*, 429. New York: McGraw-hill.

Haderer, B., & Ciolacu, M. (2022). Education 4.0: Artificial Intelligence Assisted Task-and Time Planning System. *Procedia Computer Science, 200*, 1328-1337.

Hasnine, M. N., Bui, H. T., Tran, T. T. T., Nguyen, H. T., Akçapınar, G., & Ueda, H. (2021). Students' emotion extraction and visualization for engagement detection in online learning. *Procedia Computer Science, 192*, 3423-3431.

HM Government. (2018). *Industrial Strategy Artificial Intelligence Sector Deal.* Retrieved May 21, 2022 from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/702810/180425_BEIS_AI_Sector_Deal__4_.pdf

House of Lords. (2018). *AI in the UK: ready, willing and able?.* Retrieved May 21, 2022 from https://publications.parliament.uk/pa/ld201719/ldselect/ldai/100/100.pdf?__cf_chl_tk=LdljFmgMycbF63eO8GIci.QDAg2Qp_KLV45broe0Xsw-1653148250-0-gaNycGzNCaU

ISTE. (2011). *Operational Definition of Computational Thinking for K–12 Education.* Retrieved May 24, 2022 from https://cdn.iste.org/www-root/Computational_Thinking_Operational_Definition_ISTE.pdf.

ISTE. (2018). *Bold New Program Helps Teachers and Students Explore The Power Of AI.* Retrieved 24 May, 2022 from https://www.iste.org/explore/articleDetail?articleid=2229.

Italian Government. (2021). *Strategic Program on Artificial Intelligence 2022-2024.* Retrieved May 21, 2022 from https://assets.innovazione.gov.it/1637777513-strategic-program-aiweb.pdf

K12 Computer Science Framework (n.d). Retrieved April 18, 2022 from https://k12csframework.ca/the-framework/

K12csframework. (2020). Retrieved May 15, from https://k12csframework.ca

Kandlhofer, M., Steinbauer, G., Hirschmugl-Gaisch, S., & Huber, P. (2016, October). Artificial intelligence and computer science in education: From kindergarten to university. In *2016 IEEE Frontiers in Education Conference (FIE)* (pp. 1-9). IEEE.

KCJ (n.d). Retrieved April 12, 2022 from https://kidscodejeunesse.org/about

Kim, S., Jang, Y., Choi, S., Kim, W., Jung, H., Kim, S., & Kim, H. (2021b). Analyzing teacher competency with TPACK for K-12 AI education. *KI. Künstliche Intelligenz (Oldenbourg), 35*(2), 139–151. https://doi.org/10.1007/s13218-021-00731-9

Kim, S., Jang, Y., Kim, W., Choi, S., Jung, H., Kim, S., & Kim, H. (2021a). Why and What to Teach: AI Curriculum for Elementary School. *Proceedings of the AAAI Conference on Artificial Intelligence, 35*(17), 15569-15576. https://doi.org/10.1609/aaai.v35i17.17833

Loeckx, J. (2016). Blurring boundaries in education: Context and impact of MOOCs. *International Review of Research in Open and Distributed Learning, 17*(3), 92-121.

MEB, (2019). Retrieved May 25, 2022 from https://www.meb.gov.tr/meb-egitimde-yapay-zeka-uygulamalari-icin-itu-ile-el-sikisti/haber/18720/tr

MEB, (2020). Retrieved May 25, 2022 from https://www.meb.gov.tr/bakan-selcuk-mebin-yapay-zekali-asistanini-tanitti/haber/21457/tr

Merriam, S. B. (2009). *Qualitative research. A guide to design and implementation.* San Francisco: John Wiley-Sons

National AI Initiative Act.. (2020). Retrieved May 15, 2022 from https://www.ai.gov/

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence, 2*, 100041.

OECD.AI (2022a), Retrieved May 25, 2022 from https://oecd.ai/en/dashboards/policy-initiatives?conceptUris=http:%2F%2Fkim.oecd.org%2FTaxonomy%2FGeographicalAreas%23German

OECD.AI (2022e) Retrieved May 19, 2022 from https://oecd.ai/en/dashboards/policy-initiatives?conceptUris=http:%2F%2Fkim.oecd.org%2FTaxonomy%2FGeographicalAreas%23Argentina

OECD.AI. (2022b). Retrieved May 24, 2022 from https://oecd.ai/en/dashboards/policy-initiatives/http:%2F%2Faipo.oecd.org%2F2021-data-policyInitiatives-26934

OECD.AI. (2022c). Retrieved May 21, 2022 from https://oecd.ai/en/dashboards/countries/France

OECD.AI. (2022d). Retrieved May 21, 2022 from https://oecd.ai/en/dashboards/policy-initiatives/http:%2F%2Faipo.oecd.org%2F2021-data-policyInitiatives-25374

OECD.AI. (2022f). Retrieved June 3, 2022 from https://oecd.ai/en/dashboards/policy-initiatives?conceptUris=http:%2F%2Fkim.oecd.org%2FTaxonomy%2FGeographicalAreas%23Brazil

Open Gov Asia. (2021). *Indonesia Deploys Artificial Intelligence to Accelerate Economy and Digital Transformation.* Retrieved May 24, 2022 from https://opengovasia.com/indonesia-deploys-artificial-intelligence-to-accelerate-economy-and-digital-transformation/

Oxford Insights & C Minds. (2018). *Towards an AI Strategy In Mexico: Harnessing the AI Revolution.* Retrieved May 21, 2022 from http://go.wizeline.com/rs/571-SRN-279/images/Towards-an-AI-strategy-in-Mexico.pdf

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). *Artificial intelligence in education: Challenges and opportunities for sustainable development.* UNESCO: Paris, France

Petrella, S., Miller, C., & Cooper, B. (2021). Russia's Artificial Intelligence Strategy: The Role of State-Owned Firms. *Orbis. 65*(1), 75–100.

Pokricakova, S. (2019). Preparing teachers for the application of AI-powered technologies in foreign language education. *Journal of Language and Cultural Education [online] 7(*3), 35-153.

Russian Federation Ministry of Defense, (2018). *Искусственный интеллект: проблемы и пути их решения.* Retrieved May 25, 2022 from https://mil.ru/conferences/is-intellekt.htm.

Schiff, D. (2022). Education for AI, not AI for education: The role of education and ethics in national AI policy strategies. *International Journal of Artificial Intelligence in Education, 32*(3), 527-563.

Sensetime. (2018). *Fundamentals of artificial intelligence*. East China Normal University. Retrieved from https://www.sensetime.com/en/Service/ai_class.html.

Shaikh, A., Kumar, A., Jani, K., Mitra, S., García-Tadeo, D., & Devarajan, A. (2021). The Role Of Machine Learning And Artificial Intelligence For Making A Digital Classroom And Its Sustainable Impact On Education During Covid-19. *Materials Today: Proceedings. 56,* 3211-3215

South African Government. (2021). Retrieved May 24, 2022 from https://www.gov.za/speeches/minister-khumbudzo-ntshavheni-remarks-artificial-intelligence-ai-regulation-while

Southworth, J., Migliaccio, K., Glover, J., Reed, D., McCarty, C., Brendemuhl, J., & Thomas, A. (2023). Developing a model for AI Across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education: Artificial Intelligence, 4*, 100127.

Stemler, S. E. (2015). Content analysis. *Emerging trends in the social and behavioral sciences: An Interdisciplinary, Searchable, and Linkable Resource*, 1-14.

Strategic Council for AI Technology. (2017). *Artificial Intelligence Technology Strategy.* Retrieved May 24, 2022 from https://ai-japan.s3-ap-northeast-

1.amazonaws.com/7116/0377/5269/Artificial_Intelligence_Technology_StrategyMarch2017.pdf

Su, J., & Zhong, Y. (2022). Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions. *Computers and Education: Artificial Intelligence, 3*, 100072.

Su, J., Zhong, Y., & Ng, D. T. K. (2022). A meta-review of literature on educational approaches for teaching AI at the K-12 levels in the Asia-Pacific region. *Computers and Education: Artificial Intelligence,* 100065.

Tahiru, F. (2021). AI in Education: A Systematic Literature Review. *Journal of Cases on Information Technology (JCIT), 23*(1), 1-20.

UNESCO (Ed.). (2022). *K-12 AI curricula: A mapping of government-endorsed AI curricula.*

UYZS (2021). *Ulusal Yapay Zekâ Stratejisi.* Retrieved May 24, 2022 from https://cbddo.gov.tr/SharedFolderServer/Genel/File/TR-UlusalYZStratejisi2021-2025.pdf

Villani, C., Bonnet, Y., & Rondepierre, B. (2018). *For a meaningful artificial intelligence: Towards a French and European strategy.* Conseil national du numérique.

Vincent, J. (2017). *Putin says the nation that leads in AI 'will be the ruler of the world'.* Retrieved May 25, 2022 from https://www.theverge.com/2017/9/4/16251226/russia-ai-putin-rule-the-world adresinden

Wang, Y. (2021). Educational management system of colleges and universities based on embedded system and artificial intelligence. *Microprocess. Microsystems, 82*, 103884.

Williams, R., Park, H. W., Oh, L., & Breazeal, C. (2019, July). Popbots: Designing an artificial intelligence curriculum for early childhood education. In *Proceedings of the AAAI Conference on Artificial Intelligence* (Vol. 33, No. 01, pp. 9729-9736).

Wong, G., Ma, X., Dillenbourg, P., & Huan, J. (2020). Broadening artificial intelligence education in K-12. *ACM Inroads, 11*(1), 20–29.

Yang, X. (2019). Accelerated move for AI education in China. *ECNU Review of Education, 2*(3), 347-352.

Yang, W. (2022). Artificial Intelligence education for young children: Why, what, and how in curriculum design and implementation. Computers and Education: Artificial Intelligence, 3, 100061.

Yu, L., Tang, X., Song, J., & Yu, S. (2021). *Artificial Intelligence education in K-12 Schools in the Intelligent Era: Strategic Positioning and Core Content Domains*. Distance Education in China, (5)

APPENDIX – 1

EK 1 – Documents Analysis Form

Country	Publisher	Session	Purpose	Teacher Education	Class or Level	Unit	Sub-Unit	Learning Outcomes	Activity	Tools or Programming Language	Summary

APPENDIX 2

Summary of Countries' Artificial Intelligence Curriculum

Countries / Themes	AI Teaching Objectives	Teacher Trainings	Content and Learning learning outcomes	Tools, resources, and programming languages	Age – class levels	AI teaching initiations
Germany	None Information	None Information	None Information	None Information	Elementary school, middle school, high school	It is still under development.
America	Achieving a national standard within the framework of K12	Contents such as materials, videos and software have been prepared for the development of teachers.	It consists of 5 titles: "Perception, Representation and Logical Thinking, Learning, Natural Interaction, Social Impact".	None Information	Elementary school, middle school, high school	Different initiatives are carried out in cooperation with the state and non-governmental organizations.
Australia	Students' research of the role of robots and other smart machines in society supported by artificial intelligence technologies	None Information	Within the scope of the unit titled "Robotic Applications", it has a content in which researches on robots are made together with technologies such as artificial intelligence and machine learning.	None Information	11th and 12th grade	AI technologies are included in existing curricula.

Austria	None Information	Artificial intelligence trainings for teachers are given during undergraduate education.	Under the unit "Data Science and Artificial Intelligence" of the curriculum, "Algorithms and programming, Contextual problem solving, Data literacy, application of AI to other fields, Artificial Intelligence Ethics, Social Effects of Artificial Intelligence, AI techniques, AI technologies, Artificial Intelligence Development"	Scikit-learn, Keras, Tensorflow, Jupyter Notebook/Lab, Python, PyCharm	High school	Robotics and Artificial Intelligence council was established by the state. Curriculum has been developed by government institutions.
Belgium	None Information	None Information	None Information	None Information	Preschool, primary school, middle school, high school	Efforts are being made to develop an AI curriculum at the high school level. Policies for all education levels are being developed.
Chinese	Introducing artificial intelligence to students, teaching the uses of artificial intelligence and its potential contributions to society	Teachers receive informative trainings on artificial intelligence technologies used in the classroom, which they have to attend every three years.	For preschoolers, the subject was expressed as "Disconnected activities for those who are familiar with robots or smart agents", while for the primary school group it was determined as "Basic Programming with Scratch and Python, Perceiving the environment with Arduino, Being familiar with various robots". Topics for middle school students are "Introduction to AI, AI Perceptions, use of sensors, Solving problems through data and algorithms". Topics for high school students "AI, AI Applications, AI Fundamentals, AI History, Strong	Scratch, Python, Arduino	Elementary school, middle school, high school	A curriculum at primary, secondary and high school levels has been developed in cooperation with public and private institutions. Collaboration with UNESCO.

			AI Weak AI, AI Ethics, Introduction to NLP, AI Language, Parts of Speech, Natural Language Processing, Word Vectors, Syntax Parsing, Information Extraction, Knowledge Map, Problem Solving, Logic Inference, Extending Logic Inference, Recognition Framework, Decision Tree Training, Search Engines.			
South Korea	None Information	similar to america	Modules, "(1) Introduction to AI, (2) Traditional Approaches of AI - Search and Reasoning, (3) Face Detection, (4) Speech Recognition, (5) Machine Translation, (6) Image Classification, (7) Text Classification is (8) Self-Driving Cars"	None Information	Elementary school, middle school, high school	In high schools across the country, two courses on artificial intelligence as elective courses have been added to the curriculum. Artificial intelligence curricula at primary and secondary school levels are combined with pre-existing software courses.
India	Students learn the opportunities that artificial intelligence will offer to individuals and society, students create an infrastructure on artificial intelligence applications with	Trainings and supporting materials were prepared for teachers.	Units for grades 6, 7 and 8 are "Excite, Relate, Purpose, Possibilities, AI Ethics". Units for 9th graders are "Introduction to AI, AI Project Cycle, Neural Network, Introduction to Python". Units for 10th graders are determined as "Introduction to AI, AI Project Cycle, Advance Python, Data Sciences, Computer Vision, Natural Language Processing". Units for	Microsoft Office Applications, Anaconda Navigator, Web Browser, Python	Elementary school, middle school, high school	More than one artificial intelligence teaching program has been developed. Collaboration with Intel.

	this information and use artificial intelligence effectively in the solutions of future problems.		11th grade, “Introduction to AI, AI Applications & Methodologies, Math for AI, AI Values (Ethical Decision Making), Introduction to Storytelling, Critical & Creative Thinking, Data Analysis (Computational Thinking), Regression, Classification & Clustering, It is set to AI Values (Bias Awareness). Units for 12th graders “Capstone Project, Model lifecycle, Storytelling through data”			
Hong Kong	similar to china	None Information	The units were determined as “perception, social impact, natural interaction, representation and reasoning, machine learning, deep learning”. In the content, there are topics such as “interaction with sensors, the effect of artificial intelligence on daily life, inference processes, creating and modifying applications based on perception, basic concepts related to coding and applications, Python”.	None Information	Elementary school, middle school, high school	Studies were carried out for different grade levels.
Japan					Elementary school, middle school, high school	A project to develop a curriculum based on the principles of the AI4K12 program has been initiated.

Canada	To equip people with fundamental skills in technology, artificial intelligence and machine learning in a national context	similar to america	It consists of 6 themes: “Data, Perception, Representation and Reasoning, Learning, Natural Interaction, Social Effects”. Another curriculum consists of “Programming, computing and networks, data, technology, society and design” units.	Raspberry Pi, Voiceflow, Scratch, Little Robot Friends, Glitch, Arduino, CoSpaces, Trinket, Pixlr, Canva, Piskel, Soundtrap, TinkerCad, Micro:bit, SketchUp, Lynx, ScratchJr, BeeBot, Repl.it, Makecode, Art:bit , The Algorithm Literacy Project	High school	There are three different initiatives. These; “Learning for the Digital World: A Pan-Canadian K12 Computer Science Education Framework” is an educational initiative developed by “Actua” and most recently by the non-governmental organization Kids Code Jeunesse (KCJ) and supported by both government and private sector firms. .