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A Study on the Curriculum Design for K-12 AI Education Using Knowledge Graph

Dong Hwa Kim[1*], Rojina Shakya[2]
[1]DSTSC, S. Korea
[2]Dept of AI Engineering, Kathmandu Univ., Nepal

ABSTRACT

The 4th industrial revolution, AI, and ChatGPT have been advancing up as key topics in industrial areas and educational systems. This paper deals with the educational curriculum for the effective nurturing of manpower including the ChatGPT. ChatGPT and AI are highly impacting on educational systems as well as in many industrial areas because ChatGPT can be easily used by everyone to ask questions and get responses about any field. In particular, it helps young students for composing various written content, including articles, and essays, as well as debugging and fixing code. In the coming future, millions of jobs are speculated to be replaced by AI as AI can effectively perform jobs that need automation, such as data collection and repetitive tasks. Therefore, revising education methods and curriculum systems has become a high necessity in today's time. However, the government and its representatives do not fully realize how important the change is for education. Thus, this paper provides education methods and curriculum for AI education including ChatGPT by analyzing many papers, reports, and previous experiences.

Keywords: 4KW, AI education, 4th industrial revolution, S/W Education, ChatGPT

INTRODUCTION

After playgo gaming in 2016 by Alphago, large numbers of people have been interested in AI (Artificial Intelligence) as it is an emerging technology for every area such as management, business, medical, fashion design as well as technologies and engineering. These results are also impacting on education such as teaching, learning, idea creation, education management, and so on.

That is why, many education policies and educators have started to introduce AI education for K-12 curriculum because of application of this technology and its related technologies in many life areas. But due to the lack of study and experience of teachers in K-12 education, the curriculum design has not been effectively designed and created even though curriculum design is the backbone of education.

Knowledge expression is one of tools to express the human mind (that is, idea) by knowledge structure. There are many tools to present human ideas such as fuzzy logic, natural language, logical mathematics, and others. Knowledge representation is to illustrate reason and human problem solving by knowledge graph for intelligent ideas (intelligent system) to have a solution for complex tasks.

Currently, many have been interested in AI applications in several areas and complicated issues to solve complicated social issues, engineering problems, and economic differences. Of course, deep learning and machine learning, and other learning method are also attractive in popular.

Basically, a knowledge graph is one of the methods as facts, and entities to consider relationships and semantic descriptions. Because the knowledge graph-based AI technology expresses the thinking mind as a graph structure when humans have an idea, we can understand well flow and interpretation of knowledge (thinking style) and can easily build inferences over facts. Recently, advanced technologies are trying to extend AI effective solution using another

*Corresponding Author

tool like a KGI (knowledge graph-based intelligence).

This material provides knowledge graph technology an intelligent approach for designing K-12 AI education curriculum. As the knowledge graph is one of the methods that represent the science knowledge domain as visualization, it can be a strong AI (artificial intelligence) method because it deals with knowledge (mind, idea).

Firstly, Google started the knowledge graph as a semantic network and it needs much information and data to implement the knowledge graph. The knowledge graph has functions such as discovery, understanding, communication, and education and six- application aspects of microcosmic display for specific areas, macroscopic subject visualization, education teaching course assistor, document knowledge coordination, digital library, and knowledge dissemination displaying.

Through this knowledge graph, we can clearly express the flow of overall knowledge and information, and find out which knowledge has played an important role in knowledge information decisions. We can design and construct knowledge networking situations such as curriculum, and knowledge networks.

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This paper aims as a curriculum design example for teaching AI in K-12 including grade level, which subject related to AI is effective and useful, what should a student know, and how to develop K-12 AI resources and direction.

Generally, curriculum design works for K-12 AI at schools is more complex compared to higher education and the traditional teaching method because many variations in implementation should be considered at school and there are few education materials as the AI education system has a short career.

Herein, the working hours of teachers are increasing as student's needs become more varied as well as administrative and the burdens of paperwork also increase by work based on computers. It means that it is not easy to introduce new curricula and AI-related subjects.

The aim of this paper is to offer ideas, strategies, and design examples for AI-related curriculum and education after reviewing many materials and summarization.

AI EDUCATION STATUS

AI education has two methods: AI as assistance and AI teaching. Assistance AI is to use administrative tasks, helpers for each student, and other AI technology. Many educators forecast and expect that AI will be introduced into all education systems real soon in the future as well as industrial areas and our life areas.

Therefore, many countries have policies and strategies to enhance and empower overall AI teaching as shown in Figures 1, and 2 for K-12 courses.

However, in the case of global universities such as MIT, Carnegie Mellon University, and others, they have been introducing the teaching of AI to have an initiative and to nurture AI manpower in higher education, while it is not so many in K-12 curriculum indeed.

Currently, because environment and technology patterns are dynamically changing, it is important to understand teachers' education philosophy and feasibility assessment for innovation.

Therefore, building or designing an AI-related school curriculum is strongly dependent on teachers or educators, school leaders, education officers, policymakers, and AI experts. The most important is what type of content and what kind of subject should be included in the curriculum, and what AI tools (S/W and models) are more effective for student learning and

teaching skill.

It is quite important to design a curriculum because the syllabus should include the way of assessment, appropriate content, and effective teaching methods for knowledge delivery as well as enhancing competencies through the curriculum.

Almost all traditional curricula have been providing the overall design methods in terms of several education methods and a long history. However, in the case of AI education, its history is short, and we have very few AI experts. Also, curriculum planning and design should be trusted by teachers and the education system. Furthermore, the curriculum should be sustained in the education system for a long time.

Therefore, when we design an AI curriculum, we must recognize:

- Stage 1: Curriculum preparation and development (How to prepare, How to design, and What to teach);
- Stage 2: Curriculum content (What to include in content knowledge and what effective learning designs should be adopted);
- Stage 3: Curriculum focuses on how to connect the environment around the school and the school's policy.
- Final state: Curriculum motivation (How to motivate teachers to renew the curriculum).

LITERATURE REVIEW

Figure 1 and Figure 2 show AI strategy and educational landscape in each country. We all know that 4th knowledge wave is the ICT and AI-based revolution, many advanced countries are introducing it into their educational system of K-12 as well as higher education.

Moreover, AI has many more advantages in dealing with large datasets and standardized testing than traditional methods by manual. Therefore, current AI systems are suitable for viewing learning status and transferring the status of knowledge into student's minds.

To build a constructive knowledge graph, we must consider two components such as knowledge extract, and knowledge management. The knowledge extract is to build knowledge through word segment, frequency statistics, web crawling, keyword extract, and related extraction. The knowledge management draw knowledge graph and retrieval.

Noy et al. (2019) describe that a knowledge graph has objectives of interest and connections between objectives and nodes. They mention that knowledge graphs provide structured data and factual knowledge for driving many products and building more intelligence.

Simperl et al. (2019) describe that procurement affects virtually all aspects and organizations in times of slow economic recovery and enhanced transparency. This paper provides material of ongoing work for enabling procurement data value chains through a knowledge graph-based platform with data management, analytics, and interaction.

Yu et al. (2019) offer S/W pykg2vec that provides a practical and educational platform to accelerate research in knowledge graph representation learning.

Sousa, Silva, and Pesquita (2020) proposed data mining for existing biological knowledge in the name of knowledge graph and they obtained knowledge graph-based semantic similarity application methods.

Country	Status	Date
Austria	In progress	
Belgium	In progress	
Bulgaria	Published	Dec. 2020
Croatia	In progress	
Cyprus	Published Last update	Jan. 2020 Jun. 2020
Czech Republic	Published	May 2019
Denmark	Published	Mar. 2019
Estonia	Published	Jul. 2019
Finland	Published Last update	Oct. 2017 Nov. 2020
France	Published	Mar. 2018
Germany	Published Last update	Nov. 2018 Dec. 2020
Greece	In progress	
Hungary	Published	Sept. 2020
Ireland	In progress	

Country	Status	Date
Italy	In progress	
Latvia	Published	Feb. 2020
Lithuania	Published	Mar. 2019
Luxembourg	Published	May 2019
Malta	Published	Oct. 2019
Netherlands	Published	Oct. 2019
Norway [AC]	Published	Jan. 2020
Poland	Published	Dec. 2020
Portugal	Published	Jun. 2019
Romania	In progress	
Slovakia	Published	Jul. 2019
Slovenia	Published	May 2021
Spain	Published	Dec. 2020
Sweden	Published	May 2018

Source: JRC – European Commission

Figure 1: 1 AI strategy n EU

Figure 2: AI education landscape

Ji et al. (2020) provide a basic theory method on knowledge graphs as a survey paper. This paper offers four scopes: knowledge embedding space; knowledge acquisition; knowledge graph representation; and knowledge graph application on natural language in real-world knowledge.

Aliyu, Kana, and Aliyu (2020) study university course management for automatic course generation of course allocation and easy implementation to question and answer by a knowledge graph.

The study of Sheth, Padhee, and Gyrard (2019) is a history summary paper on the knowledge graph and Python Awesome (2019) services the Python library for the knowledge

graph. Bellomarini et al. (2020) illustrated the impact of COVID-19 on the network of Italian companies and the application of legal instruments for protection by a knowledge graph.

Tabacof and Costabello (2019) offer material that studied popular embedding models and experimental results to the knowledge graph. Chen et al. (2022) show the overview of reasoning and application of the knowledge graph. The study of Peng et al. (2023) deals with opportunities and issues (AI building method on knowledge graph, potential application) of knowledge graph as one of survey paper.

Ke and Lin (2022) provide the dynamic generations of knowledge graph for interdisciplinary STEAM topics and application experiments for more reasonable STEAM learning to teachers.

CURRICULUM DESIGN BY KNOWLEDGE GRAPH

SETUP was an on-the-spot program which aligned PBL to real-world projects. It focused on project management and collaboration among trainees as the core competencies in engineering education (Kolmos et al., 2020). The selection of participants, program design and evaluation processes were proved to be effective. Generally, compared to the non-participants group, those who were selected and joined the PBL program performed a considerable higher quality and productivity of delivery. The Paired Samples Test of KPI of two groups (Table 1) revealed statistically significant difference (sig. 2-tailed = 0.000 < α = 0.05). The results indicate that there are significant differences between two groups on a variety of factors.

Why we should research for the best curriculum design

There can be many reasons to design a curriculum. In the case of K-12 education courses, young students have different knowledge and basic human philosophy from this contacting subject. Therefore, how to teach and what subjects are important for students' personalities.

- *Reducing Administrative Works by AI:* Teachers and administrative secretary have lost their duties such as management, arrangement, diagonalizing student attention, emotion, conversation, and data saving. AI also helps in various works of teachers like checking assignments, notice announcing, and paperwork for document producing.
- *Smart Content for Correct Teaching Subject by AI:* Current AI functions including ChatGPT can produce good images, stories, ideas, and history through a database. With this function, the teacher can make new ideas and the material to ensure the students' attention.
- *Smart content is a very important issue in the pedagogy system:* Robotic systems and animation content can improve students' understanding and knowledge improvement for AI and related- technologies. Many parts of these subjects have already been introduced in a classroom at the advanced country. Consequently, almost all textbooks and education systems (smart education systems) will be digitized soon, and smart education systems (learning, teaching, and communication) will provide creative methods to help enhance students' knowledge. All educators should recognize which content is useful for teaching and learning, and what content including online assistance programs, audio, and illustrative methods (video and ppt) helps students to understand and develop their personal capabilities.
- *AI will key Impact on Economic Growth:* Many have mentioned that AI and related technology are the greatest drivers of innovation, productivity, and economic growth. These technologies have been impacting and transforming every element of business and society. AI-related works are vital to the economic development of both developing and developed countries. It is estimated that AI has contributed to one-quarter of GDP growth in most developing countries during the first decade of the 21st century. For example, since 2000, ICT alone has been responsible for 25% of Kenya's economic growth, and

20% of China's. In the second half of the last decade, ICTs accounted for 34% of Japan's economic growth.

Today, ICTs account for 6% of the world's global economy. Experts explain that at a national economic level, about 80% of the benefits come from how ICT is used, applied, and deployed by companies and governments, while only 20% of the economic value of ICTs comes from a nation's ICT industry, developing ICT hardware and goods.

ICT's core technology for the 4th industrial revolution, economic and social impact is AI and related technologies. Therefore, AI pedagogy is more important for economic development.

- *AI-based Educational System will be Key Power for Manpower:* AI-powered education systems, content, and related technologies (Online or Offline) are one of the fundamental ICT skills. ICT is dramatically changing everywhere with more inventions. So, there will be a wider range of courses available online in the world the help of AI.

  Teaching and learning method should follow this megatrend and students can learn from wherever they are.

  AI can also allow us to use many data to enhance education (teaching and learning) and to create ideas. This, in turn, allows proper education planning for the future and sustains education competition in the world. That is, we must follow the megatrend of pedagogy. But if we lost time, eventually, it will be the same as technology gets cheaper over time in the hardware and software.

  A study published by e-School News indicates that by 2021, the application of AI in education and learning will be increased by 47.5%. The impact of this technology will be felt from the lowest education levels through higher learning institutions.

  This will create adaptive learning techniques with customized tools for improving the learning experiences. AI inform the students how their career paths look like depending on their goals thus assisting them beyond academics. Only time can tell the ultimate impact of AI in the education industry. If we are wondering how to get started, then most students will surely lose their time without any gain.
- *AI Curriculum should be for Personalized Learning:* In the traditional education systems, the curriculum cannot provide the personalized learning or teaching method sufficiently because the curriculum should be designed to suit as many pupils as possible by targeting 80% of the middle.

  The pupils have been also striving to obtain their knowledge and take a position. Normally, there are high classes in the top 10% and low classes in the bottom 10%. Basically, they have difficulties following along. However, when we introduce AI, teachers do not need to worry about these patterns because AI can support performing much better by offering personalized recommendations to each pupil.

  AI also can offer customized assignments as well as final exams, ensuring that students get the best possible assistance through analysis of students' data. Teachers can give intensive lectures by AI's guidance and data. AI can offer quick feedback and work directly with students.

AI Curriculum should be built up for our own education

AI is one of the computer sciences. So, all students should perform coding work with popular programming languages such as Python, Java, Julia, etc. However, among these, we must build up our own area to improve education results.

If we can do it, it is better to connect with physics, engineering, robotics, and mathematics (Algebra, Calculus, Logic, Algorithms, Probability, Statistics), and communication networking.

If some students are already understanding the software, we should better make a group teaching for sharing information and having a solution by students. Current students sometimes have a good knowledge of programming. For those, special projects should be prepared and adjusted for their level apart from normal students. Different skills among students can be developed through cooperation among students.

AI Education method should be built for our own purpose: To succeed in AI-based education (teaching and learning), first, a task force team is established to survey and prepare because all teachers cannot do well all together. As an example, in higher education, MIT (USA), Japan, S. Korea already established this AI department for undergraduate courses (BS) and MS courses.

MIT established an AI school in 2018. This is a strategy like the University of Nicosia (Cyprus). This University started in 1980 and focused on the education of Blockchain and now their reputation is one of the best in Blockchain areas. THE (Times Higher Education) ranked 90 in 2019-2020 in the world. They selected niche areas for the future and educated intensive methods by using small investments. It means that we have selected even if we do not have much funds, we can be at the highest level than others. As one example of a developing country, Kathmandu University of Nepal started the bachelor and master courses for AI education in 2020. Schools' curriculum in K-12 should be prepared for AI education under the national education system.

- *How we should Build an Effective AI-oriented Curriculum:* It is possible to have an idea in many areas for AI and AI in teaching and learning. Without clear pedagogic principles and philosophy, however, it is very difficult for AI vendors will provide products and services that address key decision-makers' perceived immediate problems, instead of more fundamental social and economic challenges. For an AI start-up in the educational sector, it is difficult to offer products and services that require a change in current educational practices.

Therefore, without clear visions and policies that put emerging technical possibilities in the broader context of the transformation of education and the future of learning, educational AI will probably be provided as solution to existing problems. Instead of renewing the system and orienting it towards the needs of a post-industrial economy and knowledge society, AI may therefore mechanize and reinvent outdated teaching practices and make them increasingly difficult to change. It may, therefore, be necessary to develop appropriate visions and policies by simultaneously creating future-oriented models for education and teaching. Creating concrete experimentation in an authentic context with teachers and experts in education is important. As AI is now very high on the policy agenda, it is too easy to generate high-level visions of the future that claim "AI is the next technical revolution". AI is now frequently called "the new electricity." It is therefore important that teachers, who often struggle with concrete demands of everyday teaching practice and new initiatives, will not be electrocuted by this new technology.

Decision of Teaching Area and Keyword for AI Teaching

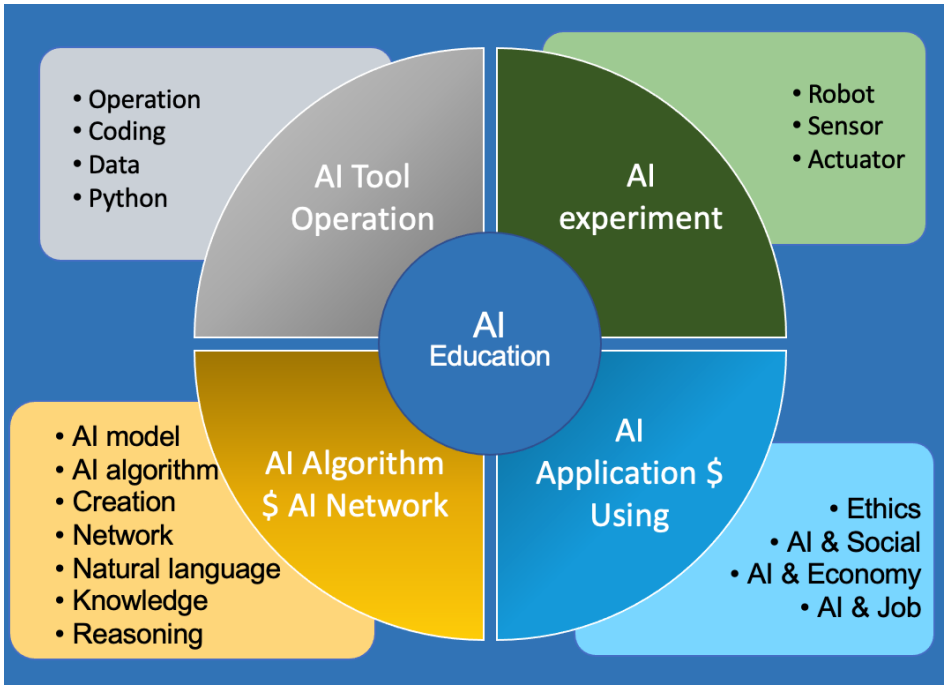


Figure 3: AI education areas and keywords

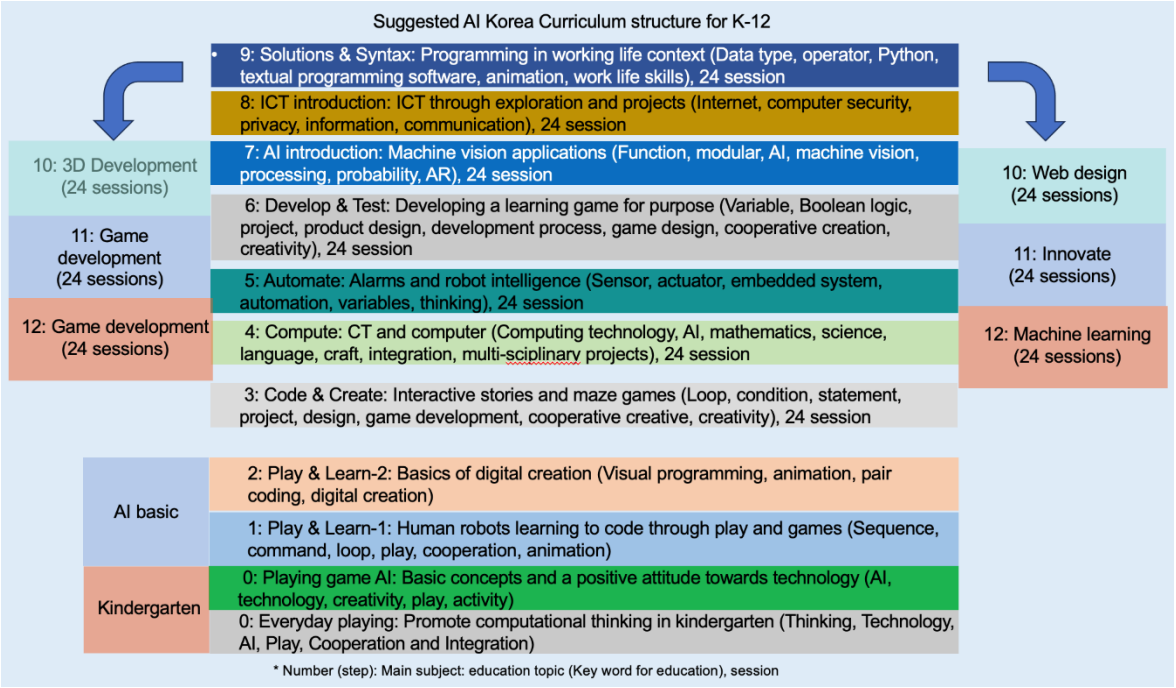


Figure 4: Curriculum schedule for AI education

However, whenever you change your areas and keywords, you must consider the key impact of your situation depending on your educational environment. Which subject is the main topic for your AI education (teaching).

Figure 4 is the teaching schedule for AI education. This schedule is from kindergarten to expert (graduate level). Therefore, all schedules should be connected and you must consider which topic is important for your situation. Of course, you develop content for AI teaching and test before running the class.

Category	Keyword	Overview course	Basic course	Middle course	Higher course	Expert course
AI Experiment	H/w	• Revolution and 4th wave • Technology pattern • Human and AI	• Sensor basic • Actuator basic • Robot basic (Selection for education target)	• H/W structure for control target • Signal flow basic • Interface basic • Control basic	• H/W operation principle • Control theory	• Self-Directed Learning and Teaching • Project-based Teaching and Learning • Project-based Self-creation • Project-based AI thinking
AI tool operation	S/W		• S/W operation (Jupiter, PC, Notebook, etc.) • Python basic coding	• Python coding • Python application for model	• Python implementation for control target and getting a data	
	Data		• Data overview • Data structure and AI	• Text data, image data, number data understanding • Data visualization • Data refine for AI	• Dominant data understanding • Useful data generation for user • Data-based AI application	
AI algorithm and AI Network	Algorithm/ Model		• AI model overview • Creation and AI thinking • Natural language overview • Knowledge and Reasoning overview	• AI model details • Creation and AI thinking theory • Natural language details • Knowledge and reasoning principle	• AI model research for user • Creation and AI thinking for the user • Natural language for user • Knowledge and reasoning for user	
	AI Network		• AI network principle	• AI network structure • Global AI network characteristics	• Global AI structure comparison (Google, MS, AWS, others)	
AI using $ Application	Application Ethics ChatGPT		• AI influence overview (AI and Ethics, AI and Social, AI and Economy, AI and Job) • ChatGPT using • AI application overview	• AI impact details (AI and Ethics, AI and Social, AI and Economy, AI and Job, AI and Technology, Art, Business) • Prompt design for ChatGPT • ChatGPt Impact (AI and Economy, AI and Job, AI and Technology, Art, Business)	• Effective AI application details (AI and Ethics, AI and Social, AI and Economy, AI and Job, AI and Technology, Art, Business) • ChatGPT application (AI and Economy, AI and Job, AI and Technology, Art, Business)	

Figure 5: Category and keyword for AI-level education

Decision to Introducing AI Teaching

Figure 6 presents curriculum design process of AI-level education when we introduce a knowledge graph into curriculum design. Of course, to finish completely, we must use related data. However, if you do not have any data after experiment, you can just modify others data for your situation.

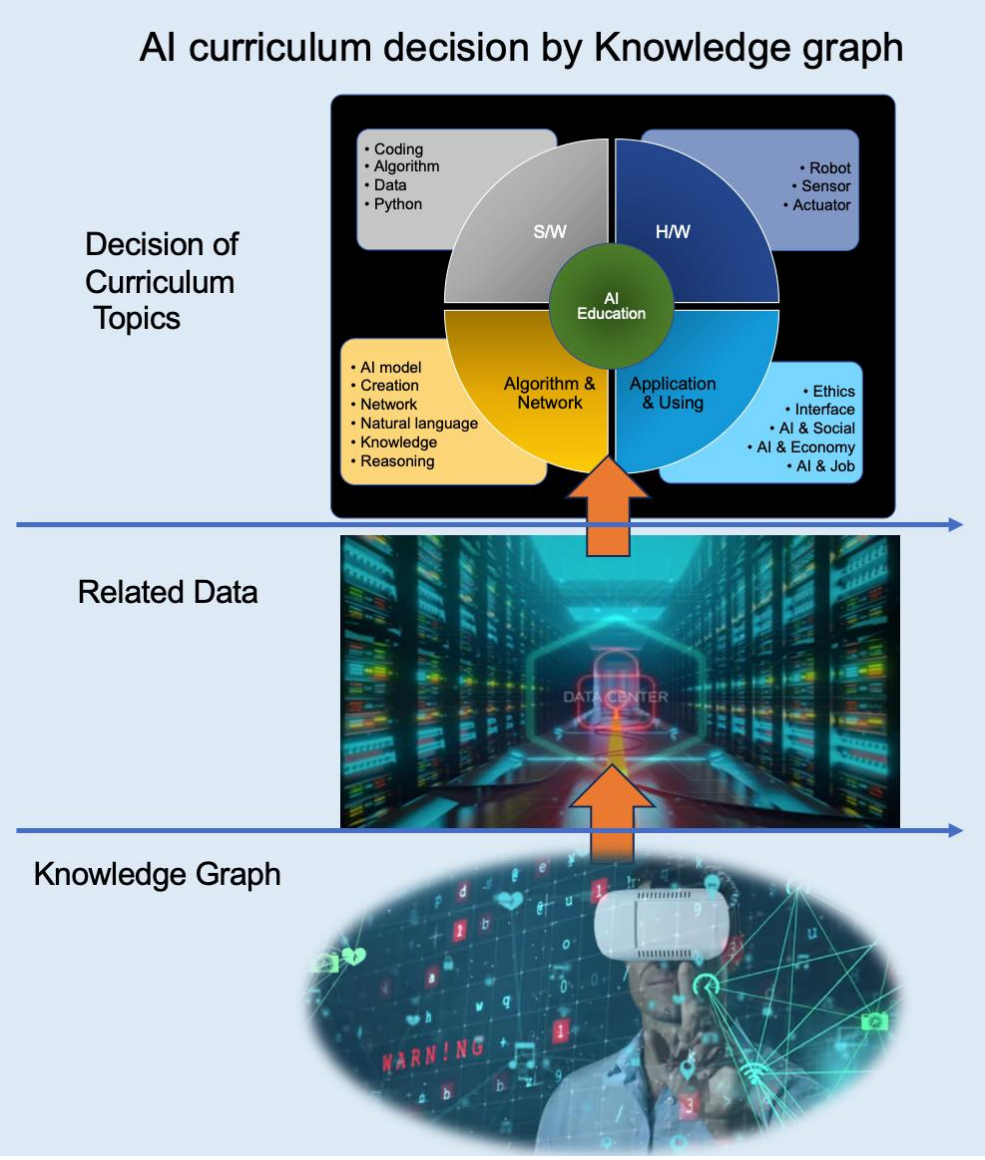


Figure 6: Curriculum design process of AI-level education by knowledge graph

Knowledge Graph Parameter Decision

Figure 7 presents the curriculum design process of AI-level education when we introduce a knowledge graph into the curriculum by considering the relation between subject and topic (keyword). The main area and subject are shown in Figure 3, 5, and 6. Figure 7 gives the relation weight function to decide how it is close or different but it is not the absolute weight number. In that case, those numbers will vary depending on the situation as described in section 4.1.

CONCLUSION

This paper deals with AI curriculum design experience through a knowledge graph. In any case, to develop and survive countries or personally, we should educate for good manpower depending on the country's situation. The biggest risk is to think that the 4th industrial revolution technologies will just be used for businesses or special government persons. We are already standing on the starting line. And also 4th industrial revolution-related technology enables businesses and make money or bigger profits.

It will impact society as a whole as already shown. It is possible for one teacher to teach many students. In the traditional education system, it is difficult to know what the students learn, and how much students understand knowledge. One of the great promises of AI is to provide large-scale analytics solutions in learning status through categorizing test results and personal data in the knowledge graph. We are going to introduce AI into the education system to connect so that they can have a chance for a job in the future. Figure 8 is an indexed relation between GDP per capital and manpower capital manpower. From this Figure 8, we see well how manpower is important. It means an effective education is quite important. Figure 9 shows elements of the educational environment influencing human capital. We can see there are many impact elements for effective AI education. Figure 10 shows AI education materials by using several toys for children's AI education. Figure 11 shows AI educational reference book for children's AI education. Figure 12 is Google Tools for Education (identified 8 emerging trends in K-12 education). With knowledge graph, we can see which subject is main role and how to design an effective AI curriculum for student’s personal characteristics. Of course, these approaches are useful for the traditional teaching curriculum.

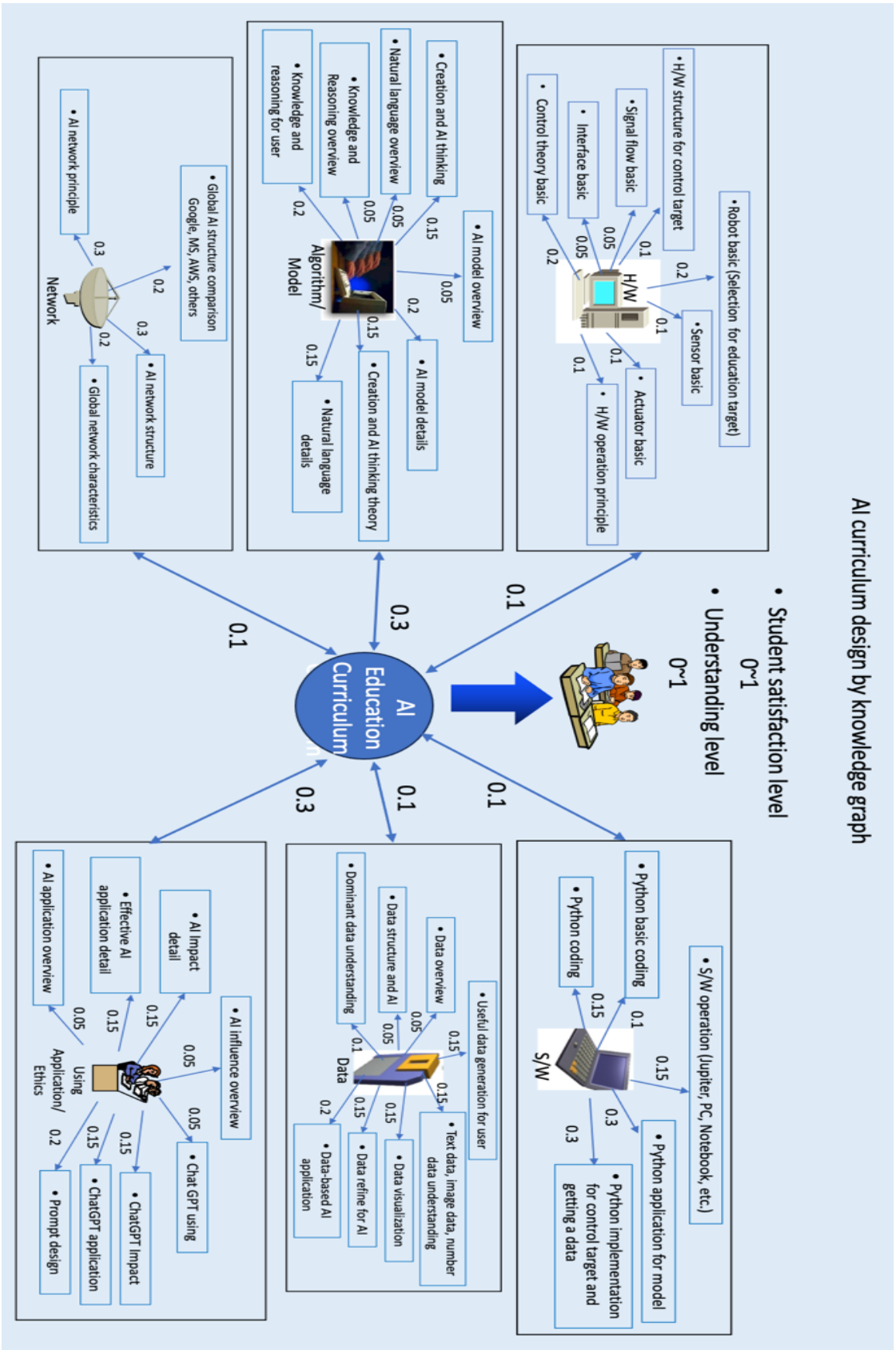
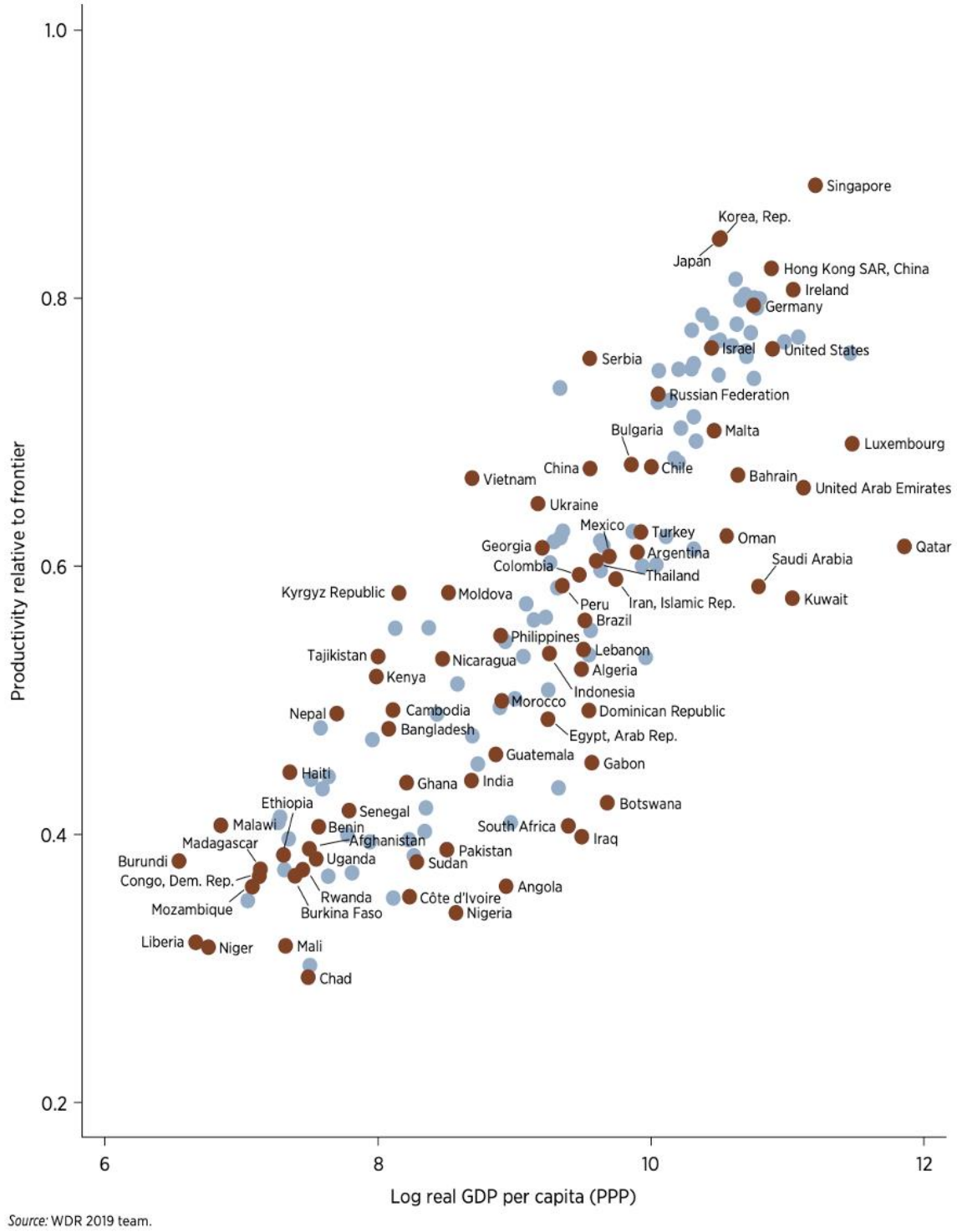


Figure 7: Curriculum design process of AI-level education by knowledge graph



Source: WDR 2019 team.

Figure 8: Relation between GDP and human capital

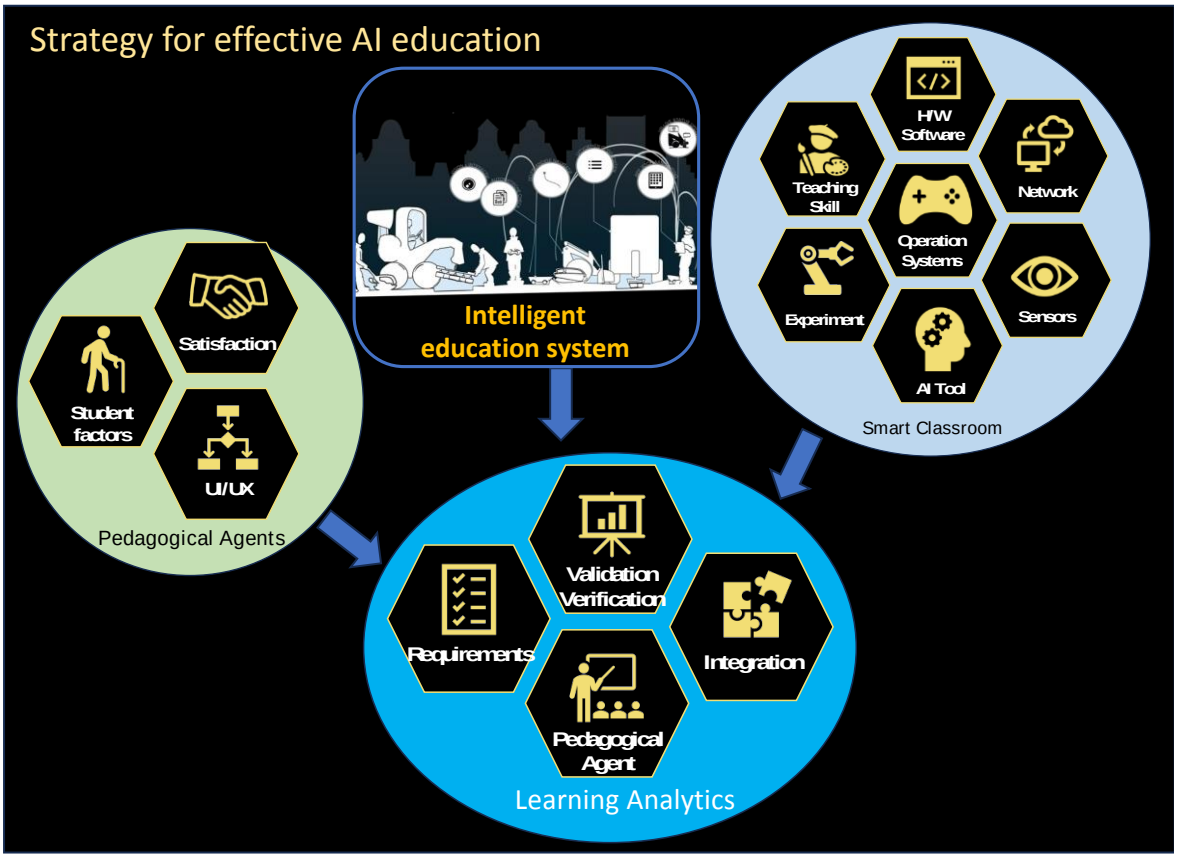


Figure 9: Elements of the educational environment influencing human capital

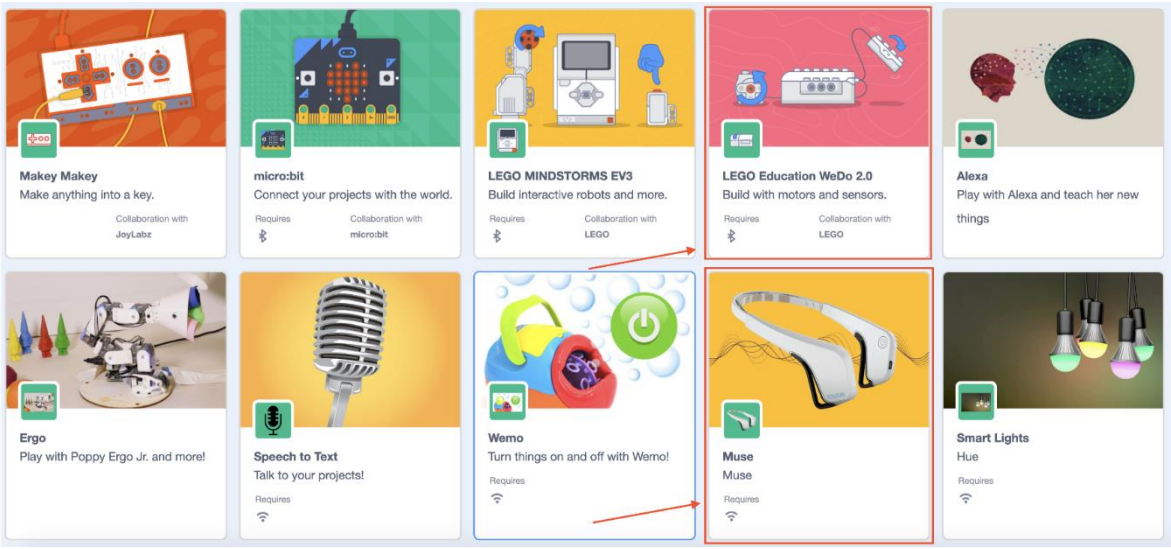
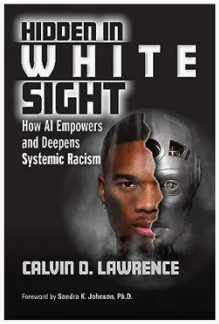


Figure 10: AI educational materials by using several toys for children's AI education (http://cognimates.me/projects/waterkinesis)



Hidden in White Sight: How AI Empowers and Deepens Systemic Racism
Calvin Lawrence | 2023년 4월 14일
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청취 가능 오디오북
US$0.00 ~~US$19.95~~
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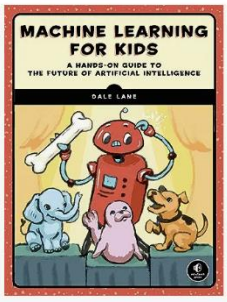

Machine Learning for Kids: A Project-Based Introduction to Artificial Intelligence
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연령대: 만 12세 이상
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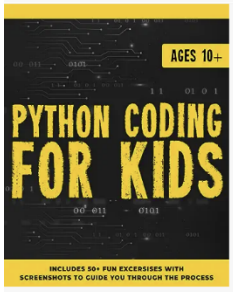

Python Coding for Kids Ages 10+: A Descriptive and Fun Guide to introduce Python Programming
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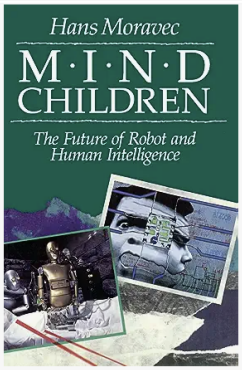

Mind Children: The Future of Robot and Human Intelligence
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Figure 11: AI educational reference book for children's AI education (https://www.amazon.com/AI-Machine-Learning-Kids-Teens/s?rh=n%3A3887%2Cp_n_feature_four_browse-bin%3A10806572011)

Figure 12: Google tools for Education (identified 8 emerging trends in K-12 education) (https://services.google.com/fh/files/misc/future_of_the_classroom_emerging_trends_in_k12_education.pdf)

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