

A Study on Pedagogy Curriculum by AI and for AI in K-12 Education

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Abstract

This paper deal with AI-based education approaches and strategies. Currently, the 4th industrial revolution has been closing up as a key topic in everywhere. Therefore, top-level universities, as well as advanced country, is redesigning to nurture good human resources by introducing AI-based education or teach for AI. The core technology of the 4th industrial revolution is AI and its related technologies. Therefore, they are introducing AI-based educational from K-12 (Kindergarten to Highschool course). However, many things are considered. This paper aims to provide strategy and method for implementation of AI-based education through analysis and review of several materials and research papers. To prepare AI-based education, we must consider the existing education system and introduce AI into the School or Department. However, its results will be up to the level of preparation of AI for all persons.

Keywords — 4th industrial revolution, AI education, education, Pedagogy.

I. INTRODUCTION

Nowadays, AI (Artificial intelligence) has been growing up as emerging technology in every technology, management, healthcare, business, and others. That technology is also giving on education, such as teaching, learning, idea creation, education management, and so on.

That is because applications of AI have been emerging in our everyday lives, many educators and education authorities have begun considering including AI topics in K-12 curricula to prepare school students to learn about these emerging technologies¹. As AI is giving on influence on rapidly, they have been considering to introduces into the education field, but teachers are most likely not familiar with its content.

While innovators among educators are creating AI curricula (to help or for teaching AI), recent application status of AI in education has highlighted the lack of study on teachers' experience and research results by experience [1, 65]. The teachers' experience needs to share and build a Curriculum in education [62, 64].

The United States announced relevant AI education initiatives in 2018 [61]. And China also has announced to

build AI initiative in 2018. The Ministry of Education of China built the “Artificial Intelligence Innovation Action Plan for Institutions of Higher Education” to encourage and support young people to participate in AI work, and teachers to teach their students AI knowledge.

Herein, the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) organized a joint to develop national guidelines for the teaching of AI to K-12 students [63, 67].

This joint working group has aims to help for developing of AI-related school curriculum. AI education in schools not only helps to obtain a future job but also to create their brain through coding and the idea.

Israel started working on National standards in 1995, the United Kingdom started computing at School, as the first country in the European Union to mandate computer science classes for all children between the ages of 5 and 16. The 18 European Countries (France, Spain, Switzerland, Slovakia, Finland, Poland, Portugal, Scandinavia, Italy, Estonia, Bulgaria, Cyprus, Czech Republic, Denmark, Greece, Ireland, Lithuania is doing for AI in education. US, India, China, Japan, Australia, and others are progressing. Especially, US is operating Website of the AI for K-12 initiative jointly sponsored by AAAI and CSTA [60-63].

Their mission is:

- Develop national guidelines for teaching AI in K-12.
 - Modelled after the CSTA standards for computing education.
 - Four grade bands: K-2, 3-5, 6-8, and 9-12.
 - What should students know?
 - What should students be able to do?
- Develop a curated AI resource directory for K-12 teachers.
- Foster a community of K-12 AI resource developers.

However, curriculum design for K-12 schools is more complex compared to higher education because many variations in implementation should be considered from School to School [4].

Working hours of teachers are increasing as student needs become more variety as well as administrative and paperwork burdens increase by work based on computer. It

¹ McKinsey, A future that works: Automation, Employment, and Productivity (2017).



means that it is not easy to introduce a new Curriculum and AI-related subject.

This paper aims to offer an idea and strategy for AI-related Curriculum and education after reviewing many materials and summarization.

II. STATUS OF AI EDUCATION

A. Impact on learning, teaching, and education

Artificial Intelligence is being employed education such as personalizing learning for each student, voice assistance, aiding educators in administrative tasks, and technology teaching [56-62].

Many are forecasting and expecting that not so far in the future, Artificial Intelligence (AI) will be introduced in all educational site as well as in our life.

AI has already started to prove its advantages and power in a wide range of educational areas, and it remains to be seen how the technology will empower and enhance overall learning outcomes in K12 courses.

On the other hand, many universities have been introducing the teaching of AI to have an initiative and to nurture AI human resources in higher education. At the same time, it is not so many in the K-12 curriculum, indeed.

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

Therefore, building or designing on AI-related school curriculum strongly depended teachers or educator, school leaders, education officers, policymakers and AI experts.

Most recent studies have been mentioning focuses on what content knowledge and what kinds of skills should be included and prepared [56] and what AI tools are more effective for student learning [61].

These researches have been mentioning several methods. However, it is not so many because the syllabus should include assessment methods and enhancing students' competencies as well as identifying appropriate content and effective delivery methods of knowledge through their curriculum.

In other words, almost AI curriculum studies have informed us well the overall design of the traditional curriculum in terms of education. Still, AI or technology-related curriculum did not include.

The curriculum planning of School is fundamentally under a political process as well as teachers' beliefs and intension.

AI teaching in K-12 can be performed under teachers' views, the school-based curriculum, teachers' preparation. That is, AI teaching is strongly concerned with:

- Curriculum preparation and development: How to prepare, to design, and teach;
- Curriculum content: What to include in content knowledge and what effective learning designs should be adopted;
- Curriculum renewal (focusing): How to connect environment around School and School's policy
- Curriculum motivation: How to get teachers to need to renew the curriculum.

B. Current situations

Currently, AI-based approaches have shown potential in educational applications. For example, as student testing plays an important role in almost educational systems, many projects have been trying to explore the use of AI for automatic test generation and assessment and reducing teacher workloads [73].

Currently, AI systems have been proved that it a very good tool in teaching assistance. For example, student homework can relatively easily be checked and diagnosed by an AI system as well as a student's career and personal check.

Many educators are also interested in AI to use to diagnose student attention, emotion, and conversation characteristics. However, informal education, they consider that AI can have both positive and negative impact on learning. As AI is now high on the policy agenda in the educational system, it may appear that the introduction of AI should be prepared in education site [69-71].

Many experts and educators believe that AI will not only make existing education more efficient, but also it will change the education system of learning and teaching.

III. LITERATURE

As 4th knowledge wave is ICT and AI-based revolution, many advanced countries are introducing into their educational system K-12 as well as higher education. Therefore, this section review on how it is doing in each area to develop the strategy of the educational system. Herein, this paper suggests a novel idea of how AI can be used in the educational system.

IBM's Watson Classroom offers cognitive solutions that help educators have an insight into the learning styles, preferences, and aptitudes of each student can provide personalized learning to a whole new level. Still, it is not obvious that such objectives would be beneficial or relevant for learning.

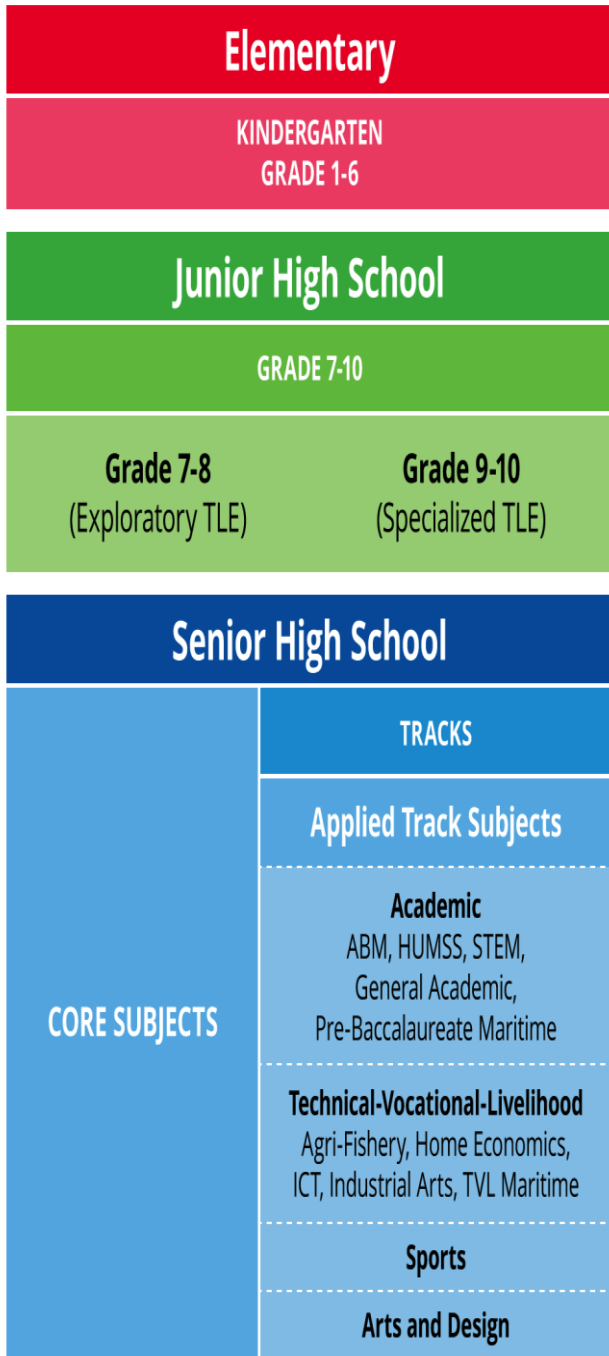
Usually, AI has more many advantages to deal with large datasets and standardized testing than traditional

methods by manual. Therefore, current neural AI systems are suitable for viewing learning status and transferring status of knowledge to the student's mind.

A. K-12 Educational Model

Figure 1 shows the Philippine model of K-12, and Figure 2 is the USA K-12 model. In figure 1, we can see the basic subject [63-65].

K TO 12 BASIC EDUCATION CURRICULUM



ALTERNATIVE LEARNING SYSTEM (ALS)- K TO 12 BASIC EDUCATION PROGRAM

Figure 1. The K-12 of Philippine.

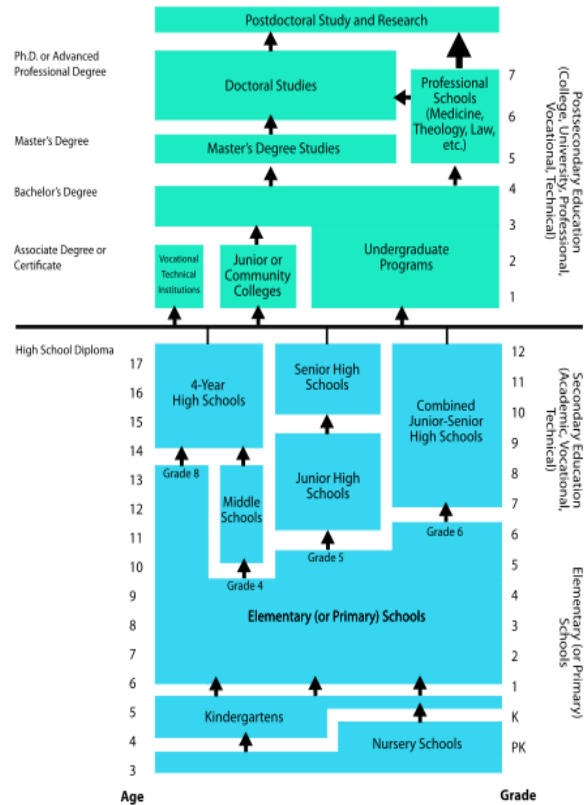


Figure 2. The K-12 of USA.

B. cognitive development by AI

Currently, many are interesting in developing of human cognition and the human brain. Recent research on neuro asks how the use of AI technologies in learning changes the brain [68].

About cognitive theory, Darwinian explanation about how the human brain has evolved^{2,3}. This idea of linkages between cognitive development and social situation.

In general, AI can be used in three essentially different ways that may have different implications for the development of human cognitive capabilities both in children and adults. By cognitive theory, we can build strategies⁴:

- Asking questions gives enhancement cognitive of students. Questions can help them dissect their learning and understanding in a certain area.
- Making a mistake can also help to learn from them. They can have a chance for their thinking to get to the correct answer.
- Fostering self-reflection/self-questioning. Giving students opportunities for self-reflection can help them

² <https://www.livescience.com/474-controversy-evolution-works.html>

³ https://www.naturaltherapypages.com.au/cognitive/nt/darwin/cognitive_behavioural_therapy

⁴ <https://www.wgu.edu/blog/what-is-cognitive-learning2003.html>

understand their mental process. Self-analysis discussions can be great ways to encourage students to think about their thinking.

- Thinking aloud can give students think aloud.

AI have a function to improve cognitive function by analysis and data. AI can also offer the need for human knowledge, experience, skill, and can emphasize the importance of behavioural repertoires.

As the development of the human brain and society were intrinsically connected, cognitive technologies may have quite fundamental consequences if used during such critical periods. It is also necessary to research for application and study in the site in education by AI for their situation.

C. The aiding of AI on teaching

To use AI in our education, first, we must know how AI can most effectively be used and given on influence in the current educational context.

That is, it is important to understand the impact of AI in the future learning and education, instead of in current systems of education and forms of learning because AI technologies have more the function of future patterns [70].

The aids of AI on teaching will, therefore, be important work on the future of teaching. The conventional intelligent systems in education don't have a student model that maintains exact information about the current state of the learner. So, it is difficult for teachers to have any information about a student's way of understanding a domain that students are learning. It is necessary to build a student's model for AI. AI-based student models and educational teaching system should be well suited for diagnostic tasks.

So far, the traditional knowledge-based intelligent tutoring systems have been getting over issues and problems of student models partly. Still, there is no obvious way to create representations of student models in complex domains and realistic context of learning and teaching.

However, AI will generate student models based on data if sufficient amounts of data are available.

D. Connection between education and society

In terms of the future technologies' pattern, the educator should not disregard AI's profound impact on education systems. This is because AI is the biggest megatrend of an ongoing broader transformation, global production, and automation of production processes as well as real-time networking of communication [56, 57].

The appropriate uses of AI in education will give rise the data, and consequently, this pattern will increase AI's function and role.

An ethics area is one of the absolute subjects that should be developed in AI application.

One of the most important is the educational policy for AI application and AI teaching and learning in the domain of the educational system. Educator, officer, and

policymakers need to understand AI in the broader context of the future of learning and teaching because educational milestone is decided from these persons.

Educators and others should understand digital technologies' pattern, the labour market, the demand for labour skills, on how fast is changing in competences, and on how the educational system should adapt, on how to create education's aim and education skills for work [60].

AI enables the automation of office works as well as many industrial productions that have been done by humans in the past. Consequently, AI is supposed to be used to reinvent current educational institutions.

It means that formal education will be diminished in creating job-related competencies and the future role of education should increase for supporting human development.

At this point, the current AI systems make almost assessment of student progress. Still, they should be used to help learners and teachers to develop their skills, competences and students and teachers can learn and teach their paths effectively.

E. AI-based Education from Knowledge Space Theory

Knowledge Space Theory uses mathematical language to define and track "knowledge points" [65].

These points form a comprehensive picture of an individual's "knowledge state" for a particular subject. There's lots of complex mathematics that goes into KST. A research paper is done by Christina Stahl and Cord Hockemeyer and offers more detail for the technically-contents⁵.

The future application of AI in education focuses on more identifying what a student does and Doesn't know through diagnostic testing because the teacher should develop personalized curricula based on each student's specific needs. For example, Assessment and Learning in Knowledge Spaces⁶ is a popular online learning platform with courses spanning K-12 through higher education⁷.

ALEKS claims to gain a precise picture of the student's level of understanding. When the student enters Learning Mode, the system then uses their assessment to adjust its curriculum to fill in their knowledge gaps.

⁵ <https://cran.r-project.org/web/packages/kst/vignettes/kst.pdf>, April 2019.

⁶ ALEKS (<https://www.aleks.com/>)

⁷ https://www.aleks.com/about_aleks/course_products

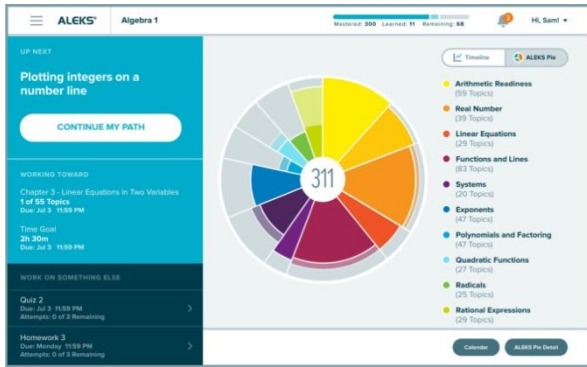


Figure 3. ALEKS syllabus.

F. AI-based Tutoring Systems (AITS)

The tutoring process is to seek ways of accomplishing more practical and realistic conditions than traditional methods. Therefore, AITS can be used in education usefully

Therefore, AITS can provide step-by-step tutorials, individualized for each student, through topics well-defined subjects such as mathematics, physics or relation among subjects through AITS based analysis.

The AITS can provide an optimal pathway through the learning materials and activities. The AITS can also guide the level of difficulty or easy, which the student can learn the given topic effectively.

G. Redesigning Education Standards

“The Center for Curriculum Redesign (CCR) is an international convening body and research centre seeking to expand humanity’s potential and improve collective prosperity by redesigning K–12 education standards for the twenty-first century.” [70]

To create a comprehensive set of frameworks, CCR brings together constituencies with diverse points of view—international organizations, jurisdictions, academic institutions, corporations, and nonprofit organizations including foundations—to consider and respond to the question: “What should students learn for the twenty-first century?”

The Center’s Guiding Principles: “A sustainable humanity—one in which collective potential is expanded, and collective prosperity improved—is orchestrated out of multiple social, economic, and environmental factors.” Among them, relevant education and curriculum are one of the important items for creation. While significant attention is which one of K–12 education is important.

What we must consider: The most important thing that we must consider is that we must prepare children to deal with greater complexity than ever before.

The major curriculum should be reformed for a time of rapidly changing needs for the twenty-first century like AI-related technologies.

We cannot expect our children’s future unless we deeply and eagerly prepare and examine. The design of curriculum related to the twenty-first century is to mean

for the young generation to be adaptable, versatile, and wise.

What we are going to redesign the AI-based curriculum is to have meaning, and we can also accomplish below:

- Development of an individual personality;
- Enhancement professional success and fulfilment;
- Understanding and ability to participate in society for sustainable humanity.

H. AI-oriented curriculum

It is possible to have an idea in many areas for AI and by AI in teaching and learning. Without clear pedagogic principles and philosophy, it is, however, very difficult that 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 startup in the educational sector, it is difficult to offer products and services that require a change in current educational practices [60].

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 mainly be provided as solutions 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 experimentations in an authentic context with teachers and experts in education is important. As AI is now very high on the policy list, it is too easy to generate high-level visions of the future that claim that 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 [62-65].

I. Teacher Beliefs about Motivating

The teachers’ belief can give an influence on motivation to deeply student’s study. That is, teachers should have professional skills.

Teachers can give on impact to all areas of the schools (both intervention and comparison schools) that can influence on for the most part taking the valuable outcomes. One area like AI can be decided intrinsic motivation in their students by teachers.

J. Economic Growth and AI Pedagogy

Many have been mentioning that Information and Communications Technology (ICT) are the greatest driver of innovation, productivity, and economic growth^{8,9,10}.

⁸ ALEKS (<https://www.aleks.com/>),

This technology has been impacting and transforming every element of business and society. ICT is vital to the economic development of both developing and developed countries. It is estimated that ICT 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 have 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 growth⁴.

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. In comparison, only 20% of the economic value of ICTs come from a nation's ICT industry, developing ICT hardware and goods.

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

Changing pattern of technologies is so fast as shown in Figure 2. From this figure, we can see why we should introduce in our K-12 program.

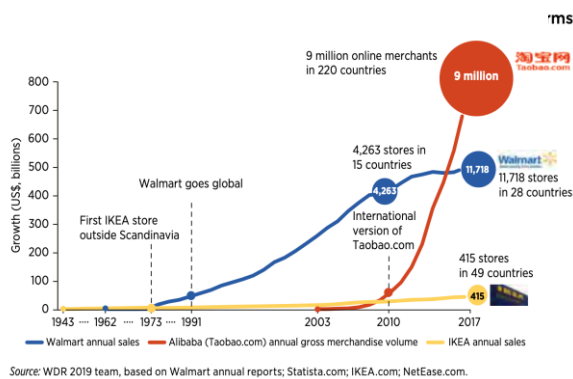


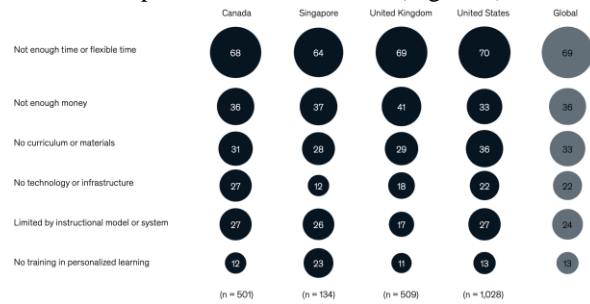
Figure 4. Recent technologies accelerate economic growth.

IV. STRATEGY BUILDING FOR AI PEDAGOGY

A. Preparation and Strategy Building for AI-based Educational System

AI-based Administrative Tasks: AI allows us to work the automatic expedition of duty administration in teachers' office and school management.

In traditional ways, educators spend a lot of time on grading exams, assessing homework, and providing valuable responses to their students (Figure 4).



Source: McKinsey Global Teacher and Student Survey

Figure 5. Teacher's blocking area for AI in each country.

But AI-based idea can be used to operate the grading tasks through the database to students. This means that educators (officer, making a poly maker, and manager) would have more time with their students rather than spending long hours grading them.

The advantage that is obtaining a lot from AI is allowing for automation of classification as well as the processing of paperwork. As the most important thing is the status of human capital, the manager should consider the human capital situation (Figure 6).

AI-based Smart Content: AI can provide a new idea and the material to ensure almost students' attention because we can use data by AI.

AI-based smart content is a very useful issue in pedagogy system. Robotic system and animation contents can produce students' understanding and knowledge improvement for new technologies. Some parts of this approach have already introduced in a classroom.

Consequently, because almost future textbooks are being digitized, new learning or teaching interfaces should be created to help students' knowledge.

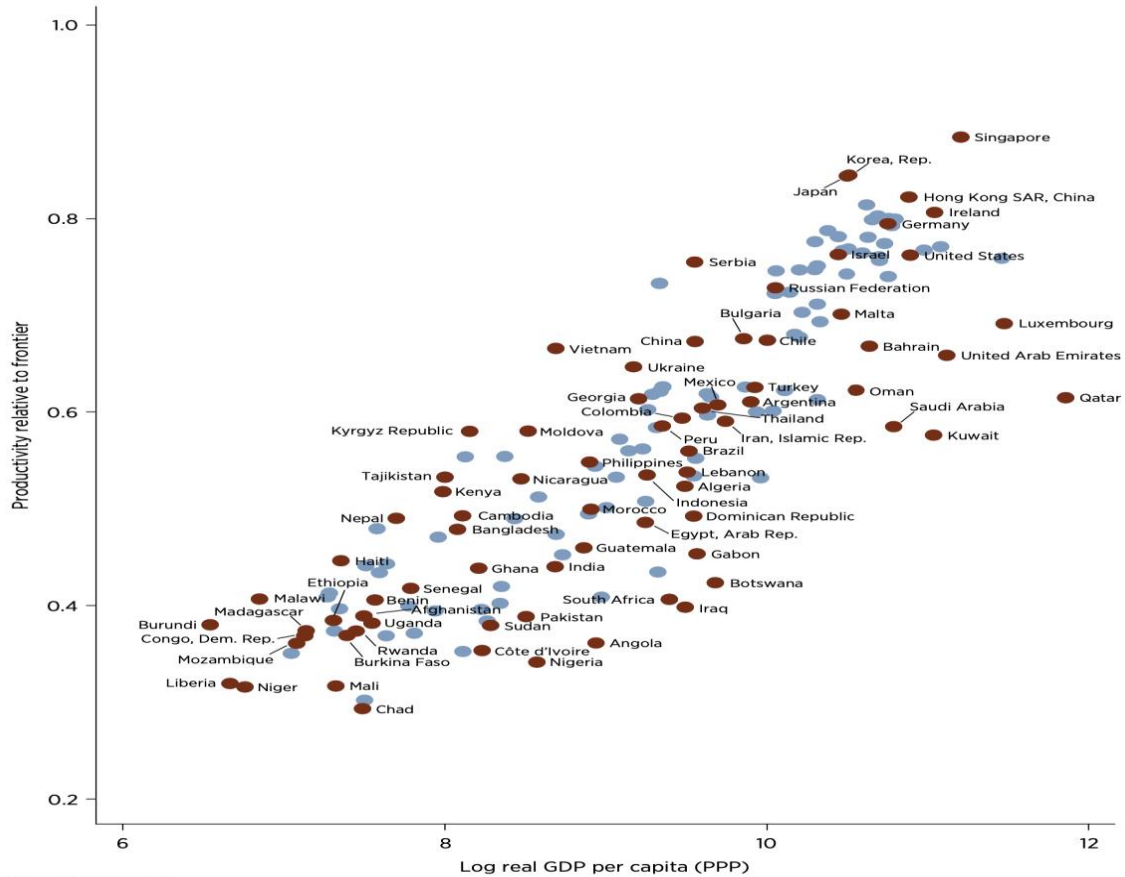
Educators should consider which content is useful for teaching and learning, and what content, including online assistance programs, audios, and illustrative method (video and ppt) enables the student to understand.

Information & Communication Technology Economic and Fiscal Impact Study, Washington Technology Industry Association, February 2015.

⁹ Social and economic impact of digital transformation on the economy, ITU, 2017.

¹⁰ Purnama, Yudi Adhi; Mitomo, Hitoshi, The impact of ICT on regional economic growth: Empirical evidence from 34 provinces of Indonesia, 2018.

FIGURE 3.3 The human capital index, 2018



Source: WDR 2019 team.

Note: The human capital index ranges between 0 and 1. The index is measured in terms of the productivity of the next generation of workers relative to the benchmark of complete education and full health. An economy in which the average worker achieves both full health and full education potential will score a value of 1 on the index. GDP = gross domestic product; PPP = purchasing power parity.

Figure 6. Human capital index of each country

B. Following the Educational Mega-Trend

The AI-powered education system, content, and related technologies (Online or Offline) are one of the fundamental ICT skills. ICT is dramatically changing in everywhere with more inventions. So, there will be a wider range of courses available online and with the help of AI in the world [23-27].

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

AI can also allow us to use any data to enhance education (teaching and learning) and to create an idea. This, in turn, allows proper education planning for the future and sustain education competition in the world. That is, we must follow the megatrend of pedagogy. If we lost on time, eventually, it is 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 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 you are wondering how to get started, then almost students will lose most of their time.

C. Curriculum 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.

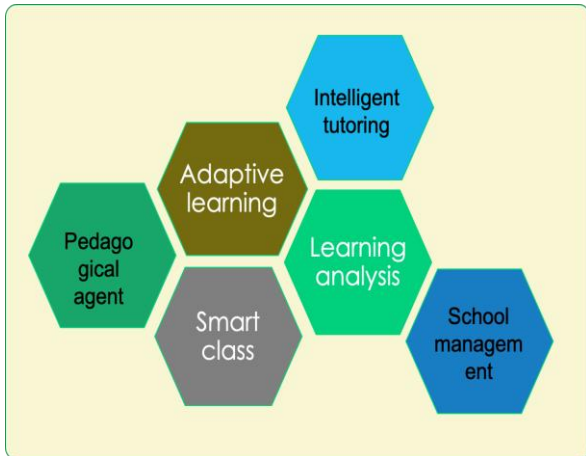


Figure 7. Strategic map for AI education¹¹.

The pupils have also been striving to obtain their knowledge and take a position. Normally, there are high class in the top 10% and low class in the bottom 10%. They have difficulties following along. However, when we introduce AI, teachers do not need to worry about these patterns because AI can support to perform 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 an intensive lecture by AI's guidance and data. AI can offer quick feedback and work directly with students.

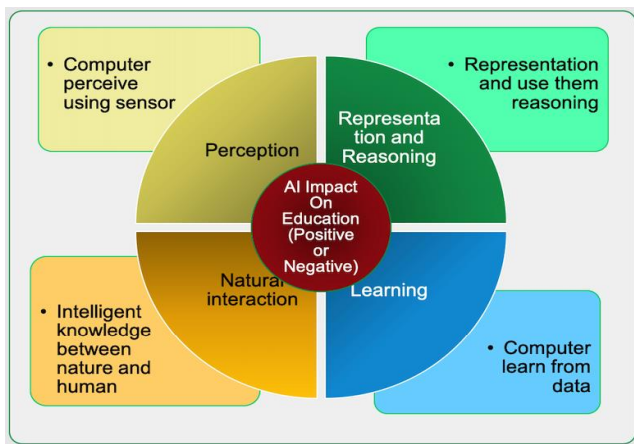


Figure 8. Education area by AI¹².

D. Building up for your 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, you must build up your area not popular. If you 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 already understand software, you had better make a group teaching for sharing information

and having a solution by students. Current students sometimes have good knowledge in programming. For those, the special project should be prepared and adjusted for their level apart from normal students. Different skill among students can be developed through cooperation among students. Figure 7 and 8 show the possible application area of AI education. Once a time, we cannot build all these courses. So, first, you must decide and select which are is the best and the biggest impact on your environment by AI. And then you can implement step by step.

Figure 9 is the teachers' working hour. Because this data is average, it will be different from your working hour. So, to reduce your School's load, you have to analyze your school system and introduce AI to obtain the biggest results.

Figure 10 represents the Google system for education. If you have a difficult to develop, you can apply this tool to your work. And you can modify and apply to others.

Figure 11, 12, is also the textbook supported by Google. To build a smart education, we have to consider many areas as we can see from Figure 6 and 7. Still, we can approach by using the traditional and commercial tool with step by step as far as we have an intension to introduce AI education.

E. Establishing AI Taskforce or Department

To succeed in AI-based education (Teaching and learning), first, the 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 at the undergraduate course (BS) and MS course. MIT established AI school in 2018.^{13,14} This is a strategy like University of Nicosia (Cyprus)¹⁵. This University started in 1980, and they focused on 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 a niche area for the future and educated intensive method by using a small investment. Undeveloped countries do not have abundant money. So, even though they do build at least one famous University and other areas can have an advantage.

Schools' Curriculum in K-12 should be prepared for AI education under the national educational system.

¹¹ Author redesign using reference.

¹² Author restructure and suggest with reference.

¹³ Dong Hwa Kim, keynote speak (CMECE2018. Aug. 24, 2018), Singapore.

¹⁴ Invited speak, University of Philippine, Sept 07, 2019, Philippine.

¹⁵ <https://www.unic.ac.cy>.

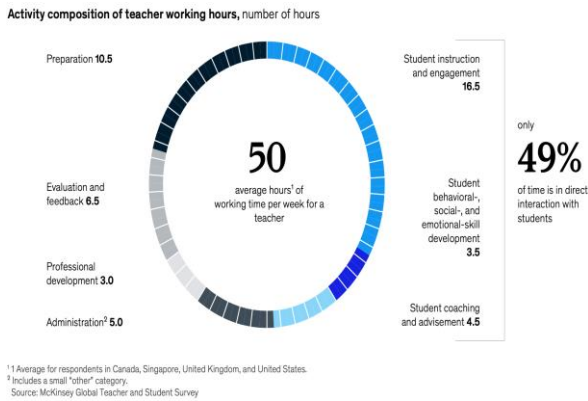


Figure 9. Teacher's working hours.



Figure 10. Google for education (identified 8 emerging trends in K-12 education).



Figure 11. AI book.

AI Books for Toddlers



Tinker Toddler Books by Dr. Handeep Dhoot

Figure 12. AI book of Google.

V. CONCLUSION

The biggest risk is to think that the 4th industrial revolution technologies will just be used for businesses or special government person. We are already standing on the starting line. And also 4th industrial revolution related technology enables businesses and making money or bigger profits.

It will impact on society as a whole as already shown. One teacher can teach many students. In the traditional education system, it is difficult to know what the students learn, how much students understand knowledge. One of the great promises of AI is to provide large-scale analytics solution in learning status through categorizing their test results and personal data.

What we are going to introduce AI into the education system is to connect that they can have a chance for a job for the future. The most important resource is human capital in the world.

The education system is the best and most important service industry. Therefore, the advanced country such as the USA, Australia, Singapore, Finland, and S. Korea have a deep strategy to nurture human resources. These countries have a good human capital index, as shown in Figure 6. These good man powers give on influence social power and lead economy.

In the 21C era, Country power will be decided by skilled and knowledgeable human resources. So, inducing of AI into your education system is quite important to develop your new pedagogy and to nurture your country's human resources.

The good educational system lies at the foundation of high-value-added services. On the other hand, with the proliferation of AI, the existent job to be disrupted, instead of that, a new job, as well as new opportunities, is created. That is why we have to introduce the AI-based education system into K-12.

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