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Reform and Development in Teacher Education for the Digital Society

Southeast Asian Ministers of Education Organization

University of Tsukuba
筑波大学

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The ***Journal of Southeast Asian Education*** is an officia Southeast Asian Ministers of Education Organization (SEAMEO) publication produced twice a year.

The main purpose of this international journal is to provide information and analyses to assist in policy-making and planning in the countries in the region. It promotes the interchange of ideas on educational issues and comparative studies, both within the countries of the region and other parts of the world. Each article in the journal was written to enable readers from outside each country to obtain an overview of how education is carried out outside its borders.

The theme of this special issue is "Reform and Development in Teacher Education for the Digital Society." It is a product of SEAMEO's collaboration with the University of Tsukuba. It features officia contributions from four SEAMEO regional centres, namely, SEAMEO Regional Open Learning Centre (SEAMOLEC), SEAMEO Regional Centre for Higher Education and Development (RIHED), SEAMEO Regional Centre for Tropical Biology (BIOTROP), and SEAMEO Regional Centre for Quality Improvement of Teachers and Education Personnel (QITEP) in Mathematics. Other contributors came from various universities and learning centres such as the University of Tsukuba (Japan), the University of Chile, Assumption University of Thailand, the Comprehensive Education Center of the Okinawa Prefecture (Japan), Nanyang Technological University (Singapore), Korea National University of Education, the University of the Philippines (UP), IPB University (Indonesia), Technological Institute of the Philippines (TIP), and Universitas Pendidikan Indonesia (UPI). The various articles in this journal present frameworks, projects, and programmes focusing on reforms and initiatives in teacher education for the digital society in Southeast Asia and beyond.

The inaugural issue of the ***Journal of Southeast Asian Education*** was launched by the SEAMEO Secretariat in July 2000.

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Foreword

Digital technologies permeate our daily tasks and interactions in the 21st century. Digital innovations are reshaping our society, economy, culture, and lifestyle. They have changed the way we learn, work, and socialise. Their ability to impact all aspects of our society cannot be overstated. Consequently, we have to reform our education system so that learners will be ready to embrace the new world they encounter every day.

The articles on reforms and initiatives in teacher education for the digital society in Southeast Asia and beyond featured in this journal highlight some of the highly effective collaboration initiatives undertaken by researchers from various universities, such as the University of Tsukuba, the University of Chile, and Assumption University of Thailand, and exemplary programmes from four of SEAMEO's regional centres that aim to improve lives across the region.

This journal, supported by the University of Tsukuba, presents good practices and examples of pioneering programmes that seek to provide recommendations and solutions to issues and challenges that address national, regional, and global educational concerns.

SEAMEO's motto, "Leading through Learning," reflects the organisation's leadership and commitment to promote quality education, science, and culture in Southeast Asia and beyond. Through the activities and strategies undertaken by its 26 regional centres and network, SEAMEO is able to reach out to diverse communities in Southeast Asia to contribute to the development of human resources (HR) and address challenging issues such as alleviating poverty, creating a better quality of life, providing educational equity and quality, enhancing agriculture and natural resources as well as health and nutrition, and promoting the dissemination and exchange of knowledge and learning of indigenous cultures and traditions.

We hope this journal serves as a source of learning and a reference for educational institutions across Southeast Asia. We are also confident that it will help the general public better understand the nature of SEAMEO's work, which will continually expand and grow as the organisation strides into a new stage of growth in the 21st century, as described in our 10-year strategic vision known as "The Golden SEAMEO."

The SEAMEO Secretariat would like to thank the ministers of education, senior official of SEAMEO member countries, and centre directors for their commitment and unfailing support over the years.

We also wish to recognise the excellent cooperation we have received from the University of Tsukuba, SEAMEO regional centres, and other partner organisations. All of these effo ts have, in one way or another, contributed to the completion of this journal.

Dr. Ethel Agnes P. Valenzuela
SEAMEO Secretariat Director

Introduction

The world has become increasingly interconnected aided by advancements in technology. As such, it has become necessary for countries the world over to reform education systems to keep up with the wave of globalisation in the 21st century. As we continue to embrace the Fourth Industrial Revolution, so should we welcome Society 5.0 and strive to become a digital society.

The SEAMEO Secretariat, in collaboration with the University of Tsukuba, embarked on various projects and programmes to contribute to effo ts towards preparing people for participating in the digital society via improving education throughout the Southeast Asian region.

Educational institutions worldwide revised their curricula in response to advancements in technology and prepare learners for life in the digital era. To get a glimpse of the developments and progress made to education systems in Southeast Asia and Japan, this journal features the following articles:

- **A Framework for Computational Thinking in Preparation for Transitioning to a Super Smart Society:** This article espouses the need to start designing a curriculum that prepares all students for a super smart ecosystem. It pushes a framework that teaches them to think like early adopters, such as computer scientists and engineers. The framework serves as a tool to improve their understanding of nature and the society and help them design and build solutions. Students have to become part of the super smart environment but they would need the right values and attitudes to handle the anxieties that come with this huge transition.

- **Transforming Modern Society and Teacher Training to Develop Creative Teachers:** This article aims to examine the changes made to Japan's education system in response to the Fourth Industrial Revolution as the country aspires to transition to Society 5.0. It enumerates the characteristics that creative teachers should have, which may require knowledge of artificial intelligence (AI) and virtual reality (VR).

- **Competency and Capability Development for Science Teacher Training in Japan:** This article provides an overview of the institutional framework for science teacher training in Japan, gives a representative example of science lesson study and the teacher license renewal system, and showcases a concrete image of science teacher training.

- **Teaching Standards and Competency Improvement Programmes: The Case of Okinawa Prefecture in Japan:** This article provides the newest Japanese in-service teacher training system as used by the Okinawa Comprehensive Education Center. It provides a bird's eye view of professional development in Japan by enumerating Okinawa's teaching standards. By doing so, it illustrates how the country's teacher training programme develops teachers' competency in curriculum management and shows how Okinawa's teacher training centre supports every school to establish an excellent learning community that produces and implements curricula through lesson study.

- **Inspecting Proactive Methods to Improve the Competencies and Capabilities of Japan's Science Teachers through Teacher Training: A Practical Example of the Foundation of Themed Research on Science Teacher Training:** This article provides a practical example as the foundation for themed research on science teacher training to help teachers embody the concept of constant learning through proactive methods so they can form and improve their own competencies and capabilities. Through a specific example of a uniquely themed research, teachers can proactively form and improve their competencies and capabilities.

- **A New Framework for Statistical Thinking in the Time of Big Data and the Digital Economy:** This article introduces a five-phase framework for the statistical thinking needed for dealing with big data via AI-driven data analytics platforms. The five phases identified in the framework are patterns and relationships from data, questions, objectives, data mining, and designing. The framework describes how statistical thinking processes have evolved from traditional question-then-answer analyses into a more creative approach. An exemplar application related to aging population issues is provided, along with a step-by-step description of the statistical thinking processes involved, to illustrate how the proposed framework can be implemented in school.

- **Mathematics Education for Future-Ready Learners: A Singapore Experience:** This article presents an alternative paradigm for teaching mathematics—not through the usual textbook approach but by using comics and associated pedagogies. It is more useful to equip students with the skills to acquire knowledge by using contexts that they are likely to encounter in the future.

- **Suggesting Interdisciplinary Teacher Education for the Fourth Industrial Revolution: A Korean Perspective:** This article presents a new direction for teacher education in Korea. It aims to help teachers develop the ability to lead "convergence" and "creativity," which are crucial to making the Fourth Industrial Revolution sustainable.

- **Supporting Reforms and Developments in Teacher Education for the Digital Economy:** This article presents the initiatives that UP National Institute for Science and Mathematics Education Development (NISMED) spearheads to address specific domains and strands. It particularly focuses on three domains—content knowledge and pedagogy, curriculum and planning, and personal growth and professional development. The kind of support that UP NISMED extends through its various programmes and projects address these domains and strands simultaneously.

- **Innovating Education in Response to the Opportunities and Challenges Related to the Digital Industry:** This article elaborates SEAMEO SEAMOLEC's undertaking in cooperation with the West Java Provincial Education Offic to develop models for open high and distance learning vocational schools. It aims to improve access to, the quality of, and the relevance of secondary education through a distance learning system in Indonesia, specifically in the West Java province.

- **Teacher Education in the Age of the Digital Economy: SEAMEO RIHED's Initiatives to Foster Key Skills for the Teachers of Today and the Future:** This article describes SEAMEO RIHED's progress with regard to the Asian International Mobility for Students (AIMS) Programme. It examines how mobility not only strengthens students' acquisition of academic knowledge but also nurtures their non-cognitive skills. It aims to highlight the potential role of student mobility in shaping key qualities required for teaching professions in the age of the digital economy.

- **Real-Time Participatory Mapping for a Disaster and Emergency Preparedness System: A Case Study of Teacher Involvement in Centre Sulawesi-Indonesia:** This article aims to present SEAMEO BIOTROP's research on responding to emergencies spurred by natural disasters, such as an earthquake that led to a tsunami that affec ed Palu in Centre Sulawesi, Indonesia.

- **STEM Village: Promoting and Spreading Awareness about STEM to Families and the Society:** This article discusses the Science, Technology, Engineering, and Mathematics (STEM) Village, a project of SEAMEO QITEP in Mathematics that attempts to create out-of-school activities designed for children and their families to spread awareness about STEM.

- **Academic Mobility Strategies and Challenges: The TIP Experience:** This article presents the strategies and actions taken by TIP to meet challenges related to academic mobility, specificall , its participation in SEAMEO's SEA-Teacher Programme.

- **Improving Academic Competence and Global Engagement: Student Participation in SEA-Teacher and SEA-TVET:** This article presents UPI's participation in two student mobility programmes—SEA-Teacher and SEA-TVET.

To learn more about the currently existing movement in education related to digital society programmes and projects throughout Southeast Asia, read the articles in this journal. They feature experiences and good practices that other countries who wish to follow suit can gain insights from. They also highlight challenges that implementers may face and have to deal with. Be inspired by their endeavours and go on your own journey towards using advanced technologies in education to prepare learners to live in a digital society and meet 21st-century challenges head-on.

A Framework for Computational Thinking in Preparation for Transitioning to a Super Smart Society

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Abstract

As never before, technological change is accelerating and it is doing so in areas that will have a strong impact on the nature of work (Collier, 2018; Japan Science and Technology Policy, 2018; and Kano, 2019). Smart machines are increasingly becoming ubiquitous and actively interacting with people and networks. This technological change has strong social consequences, including displacing many workers and leaving them practically irrelevant. At the same time, it provides others with multiple job opportunities. As such, we urgently need to start designing a curriculum that prepares all students for a new super smart ecosystem. We need a framework that teaches them to think like early adopters, such as computer scientists and engineers. Students need to learn to think the way experts do to improve their understanding of nature and the society and design and build solutions. In addition, we need students to join the super smart environment as critical citizens with values and attitudes that allow them to handle the anxieties that come with this huge transition.

Keywords: Computational thinking, super smart society, digital skills, STEAM Education

Who Takes the Initiative? You, Me, or Computers?

Imagine a super smart ecosystem, where your smartphone not only gives you instructions to turn right on the next corner to help you effectively arrive on time for your meeting, but also takes the initiative to suggest you change your presentation strategy, given the recent updates about the participants, their viewpoints, and the news of the day. Why would you follow these suggestions? What happens if a second system also takes the initiative and gives you diffe ent suggestions? What happens if the systems take the extra initiative to talk to each other and ponder their arguments but in the end, don't agree on certain key strategies? What would you do if 10 diffe ent systems take the initiative to interact with you and among themselves to help you? Welcome to a new fascinating world, which has been dubbed "the super smart society" (Japan Science and Technology Policy, 2018).

How do we prepare for this world? On one hand, the natural response is studying longer. Yes, this solution is already happening. For example, in Chile, every year, all parents of fourth-grade students are asked what academic grade their children will achieve. This is a question about their expectations (as opposed to their aspirations). More precisely, they are asked to answer the question, "What do you think is the highest level of education that your student will achieve in the future?" They are asked to choose from these answers:

- Elementary school (incomplete)
- Elementary school (complete)
- High school (incomplete)
- Vocational high school (complete)
- Regular high school (complete)
- Technical college (complete)
- University degree
- Postgraduate degree

From a total of 2,376,690 parents, 2,158,925 answered the question. As shown in Figure 1 (Araya, et al., 2017), in the last 10 years, parental expectations grew systematically. They did so for parents from all socioeconomic backgrounds and across all levels of academic performance (measured in the SIMCE national test).

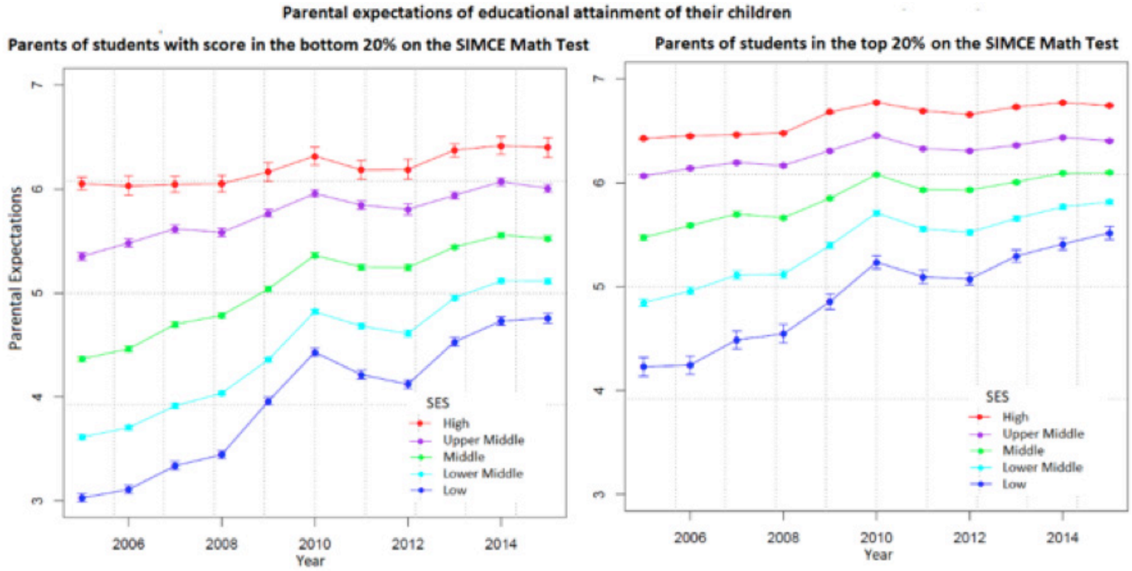

Figure 1: 2005 and 2015 parental expectations regarding their children's academic future in relation to their SIMCE math test scores broken down by socioeconomic status

Is studying more years enough? Or does it just have the same result? Do students need to learn other contents and practices? To help answer these questions, we need to review human history and primary societal transitions. We can categorise the evolution of human society into five eras, as shown in Figure 2.

Figure 2: Five society eras

Society 1.0 is the hunter-gatherer stage of human development. Society 2.0 is the agrarian society. Society 3.0 is the industrial society. Society 4.0 is the information society—the one we are living in now. Note, though, that we are slowly entering Society 5.0—the super smart society (Japan Science and Technology Policy, 2018).

Let us follow the transitions in Figure 2. Imagine you were living during the transition period from the hunter-gatherer to the agricultural society. How would you prepare the youth? How would you design the curriculum for this transition? What contents and skills should the new curriculum espouse? Do students need to learn more about hunting?

Now, imagine you were in the middle of the next transition—from the agricultural to the industrial society. What new contents should the curriculum have? Clearly, students need new knowledge and skills. The same thing happens when transitioning from the industrial to the information society. It is not enough to increase the number of years students spend in school.

In all these social transitions, it is convenient to know how those who lived before adapted. But it makes more sense to study successful cases.

Hunter-gatherers had to learn from the first farmers who adapted quickly and successfully to the next society. They needed to acquire an agricultural mindset. They needed to learn to think like successful farmers. They had to adopt their attitudes and values on top of acquiring the knowledge to grow plants. Their families, properties, and values also changed.

Knowledge and values go together. Likewise, in the next transition, it will be convenient for farmers to learn to think like the first industrialists. They need to acquire an industrial mindset. They need to learn things like measuring time, the concept of division of labour, how to use a conveyor belt, accounting, and efficienc metrics. Again, their values and attitudes should also change. The change led the population to move to large cities. They had to learn to live with others whose culture is unfamiliar. They need to adjust to the fact that despite interacting with some people, they are likely to never see them again.

The transition to the information society required yet another way of thinking—one that starts from universal literacy and numeracy. We needed to gather more information from manuals, reports, news articles, books, and the Internet. We were introduced to powerful and enormous databases. Our values also changed. Just think about your current trust in credit cards and virtual money.

But though the information we already have seems huge and it continues to grow it is however information without initiative. Vast databases are now being used, but they cannot act on their own and do not talk to one another autonomously. That may no longer be the case in a super smart society, where we expect information and devices to have initiative. They will constantly work for us. They will analyse information, deliberate with others, and even make decisions for us. And these decisions will affect us even if our sma t devices do not let us know.

What kind of mindset do we need now to be ready to transition to a super smart society? The logical strategy is to learn how successful and forward-thinking actors think. We need to think like computer scientists and computer engineers.

Welcome to Computational Thinking, Are You Anxious?

Peter Turchin, in his book, ***Ultra Society: How 10,000 Years of War Made Humans the Greatest Cooperators on Earth***, emphasises that projectile weapons are some of the most important technologies that shaped human evolution but they rarely get the credit they deserve. People tend to be much more preoccupied with fi e. But with a spear, you have a huge advantage over the rest of the members of your tribe. Your hunting productivity explodes. No one can come close. And so you also achieve enormous power. You can rule the world. But if others learn to make spears and use them, then something magical occurs—power is equalised. This situation seems more egalitarian than when nobody had a spear. Before, the strongest person hunted more and imposed his/her will over others. But when everyone owned and used spears, productivity diffe ences disappeared. Society was equalised. As Turchin (2016) put it, "It is hard to see how egalitarianism ensued without projectile weapons."

What happened? Apparently, a new technology can disrupt society and bring about inequality. Within a specific time window, the early adopters gain an almost unfair advantage. But once everyone assimilates it, the society equalizes. The initial advantage disappeared, making everyone equal. Will that always hold true?

In their influential article, "The Race between Education and Technology," Claudia Goldin and Lawrence Kats (2008) argued that the 20th century is characterised by two inequality tales where one declines and the other rises. In particular, we witnessed a sharp of college wage premium from 1915 to 1950, rose and fell from 1950 to 1980, and rapidly increased after 1980. Goldin and Kats believed that the recent decades' rising wage inequality can be traced to an increase in educational wage diffe entials. They concluded that technological changes thus create winners and losers, which can sometimes have adverse distributional consequences that may lead to social tension. Does this follow the same phenomenon seen with projectile weapons?

Nobel Prize-winning economist, Angus Deaton, in his book, ***The Great Escape***, documented the enormous improvement in poverty and life expectancies in the last few centuries. But now, we are again seeing increased inequality. According to Deaton (2013), economists attribute the ensuing wage inequality to the relentless increase in the skills required to work with new information-based technologies. The acceleration of skill-biased technical progress over the past 30 years is the main engine driving inequality in earnings. Therefore, we must not only seek new knowledge and think like early adopters but also mimic their values and attitudes. And we must do so quickly and help everyone else do the same to avoid an imbalance that can result in social tensions between early adopters and those left behind.

Framework for Computational Thinking

Based on a review of the literature, we propose that the three pillars of computational thinking be included in the curriculum. We also illustrate our proposal with exemplars. The proposed framework is meant to serve as a tool to develop basic human characteristics, creative human capital, and well-qualified citi ens through computational thinking.

First, we considered the classical context of computational thinking. It is characterised by attempting to think computationally as exemplified by philosophers and mathematicians, such as Ramón Llull, Gottfried Wilhelm Leibniz, Alan Turing, and John Holland.

For example, in a letter to Philip Spencer in 1685, Leibniz wrote, "The only way to rectify our reasoning is to make them as tangible as those of the mathematicians so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate without further ado to see who is right." Leibnitz was influenced by the work of 14th century Majorcan philosopher, Ramon Llull, who designed a mechanical machine to reformulate arguments and ideas in terms of a universal language to make them computable.

According to Llull (1305), the machine could prove the truth or fallacy of a postulate. That means decomposing arguments into thousands of simple units, which can be recombined and thus expressed as mechanical computations.

In 1936, Alan Turing proposed a sequential machine—the Turing machine—which provides a precise definition of computational steps and algorithms. This became the foundation of computational thinking as expressed today by computer scientist, Jeannette Wing (2014), who said, "Computational thinking refers to the thought processes involved in formulating a problem and expressing its solutions in a way that a computer-human or machine- can effectively car y out."

Imagine you have to write the instructions to represent quantities with an abacus. Is this an example of computational thinking? How about writing instructions to translate abacus annotations into Arabic positional notations in an article?

Figure 3: Does using an abacus require computational thinking?

Consider now the text in Figure 4. If you have to write an instruction manual to read and translate the text into English, is that computational thinking? How about an instruction manual to translate text to speech specifically in English? Is that an example of computational thinking? What if you consider the inverse—translating speech to text? Is that computational thinking? Does your smartphone do computational thinking when it uses text-to-speech or voice recognition apps?

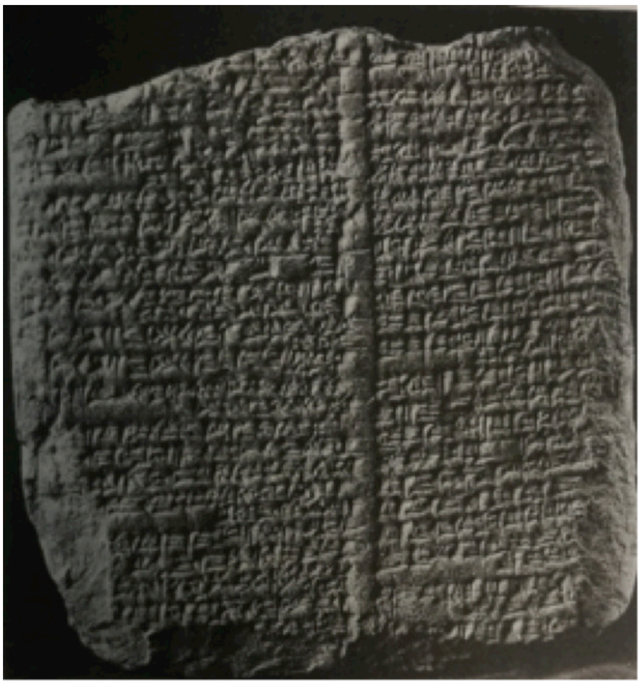

Figure 4: Does reading text require computational thinking?

The second context of computational thinking comes from science, which views it as something akin to building computational models. According to computer scientist, Peter Denning, “In the 1960s and 1970s, we allowed and even encouraged people to perceive that ‘computer science = programming,’ which is now, to our dismay, widely accepted outside the field ” Rather, he considers computational thinking as the thought process required to do computational science—designing, testing, and using computational models. According to Denning (2017), computational thinking came into wide use in the 1980s, when computational models that produced startling new discoveries in physics led him to win a Nobel Prize. Building models not only relies on abstractions like numbers and computing with numbers. It uses also the human ability to recognise patterns and the dynamics of unfolding.

Imagine a classroom floor with lots of large and small balls while each student holds a paper clip of varying sizes as shown in Figure 5. It is logical that students with large paper clips can grab small and large balls alike. The students with small paper clips, of course, will only be able to grab small balls. If you blow a whistle and give the students a few seconds to grab as many balls as they can, what do you think will happen?

Ask the students that were not able to grab any balls to put their used paper clips in a bag. You can liken those paper clips to humans without offspring in generation 1. The used paper clips that belonged to students who were able to grab balls can be likened to humans with offspring in the same generation.

Give the students who grabbed balls two paper clips of the same size each. Follow the same procedure. The results will correspond to generation 2.

What do you think will happen after several generations? Will a pattern emerge? Is the activity a demonstration of computational thinking? Are the results analogous to the sizes of bird beaks that Charles Darwin observed in the Galapagos Islands? Does the activity demonstrate natural selection?

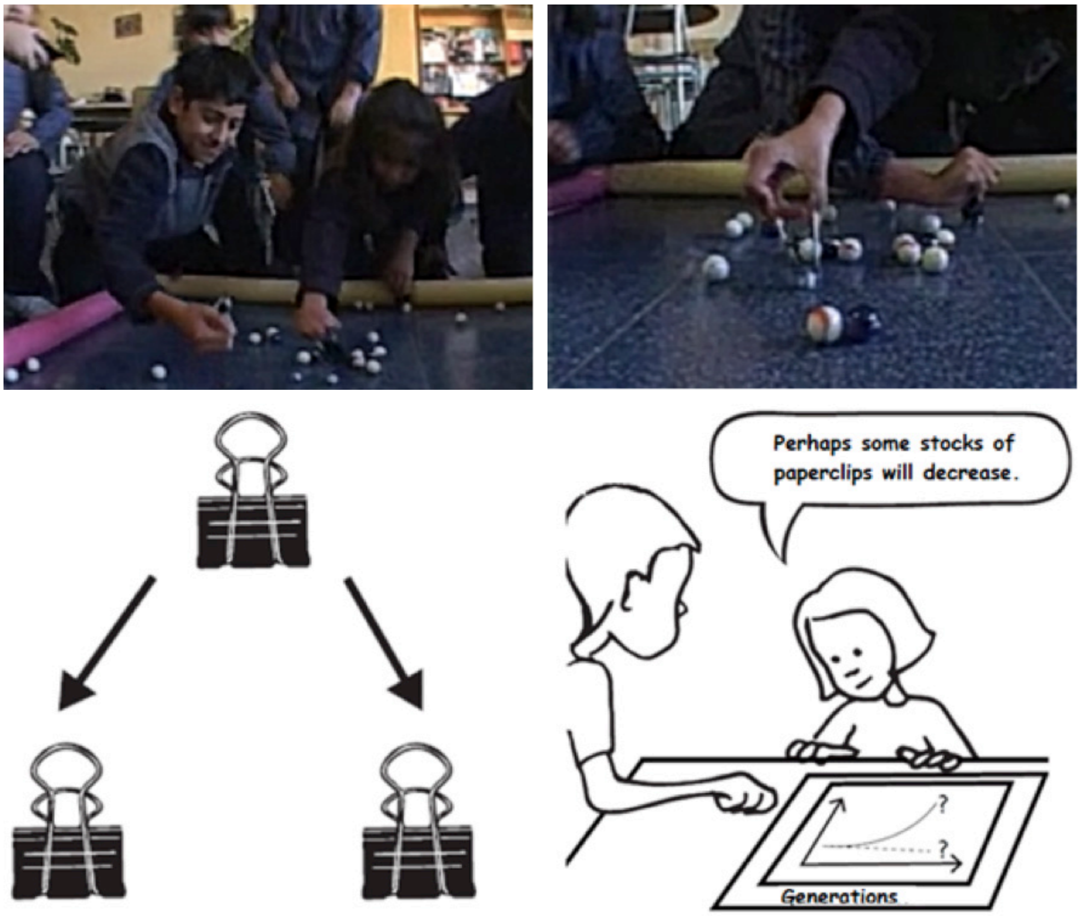

Figure 5: Students grasping balls with paper clips. Some reproduce and have similar offspring. an the students see eventual patterns regarding the paper clip population?

Computational thinking lies behind the progress made in biology that allows us to build increasingly accurate computational models of cells and organisms. According to John Holland, a pioneer in applying cellular automata to biology and the creator of genetic algorithms, pattern formations can be expressed using board games. Holland (1999) stated, "Board games are not usually accorded the same primacy as numbers but to my mind, they are an equally important cornerstone of scientific endeavour. I think board games, like numbers, form a watershed of the human perception of the world." He also introduced computational models that can evolve by mimicking natural selection to solve problems that their creators do not fully understand.

If we think of the world as a board game and people as game pieces that move following certain rules, are we demonstrating computational thinking?

Nobel Prize winner, Thomas Schelling (1978), sought to find out. He placed blue and red pieces on a chessboard and moved them around following a set of rules. He likened the board to a city and each square on it represented a house or lot. He used the game pieces to represent members of two groups, such as races of people. Schelling showed that even if people do not mind being surrounded by others of a diffe ent race, they would still choose to be with those they identify with over time. Why? Does this model demonstrate computational thinking?

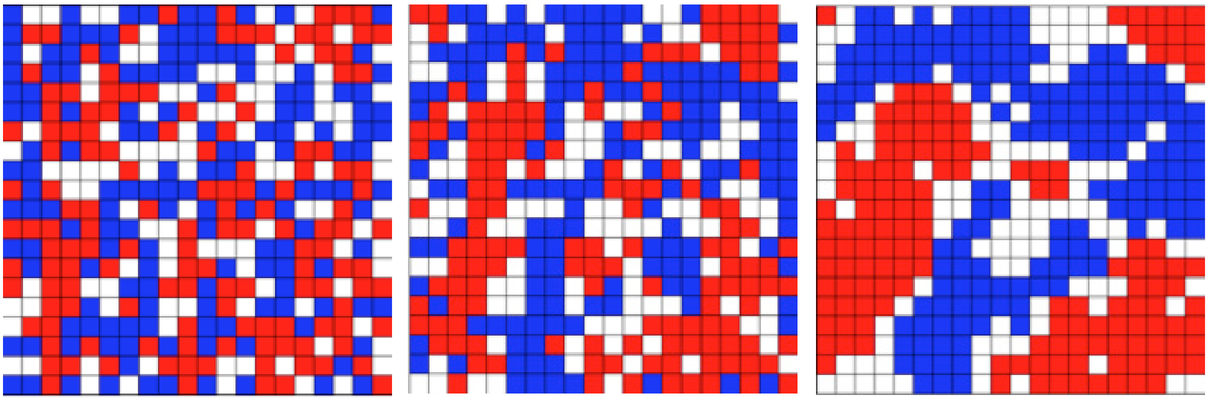

Figure 6: Initial, intermediate, and final stages of a chessboa d with blue and red game pieces. Note that in each stage, a person considers who is next to him/her. If the majority of those around him/her is of a diffe ent colour, he/she jumps to a free spot closer to his/her own kind.

Consider Figure 7 next. In it, the red dots represent non-professionals who only finished high school. The blue dots represent professionals who have college degrees. Start by distributing the dots randomly. Do you notice how after several iterations,blue dots would accumulate in certain regions? What rules can generate this behaviour? Does the activity demonstrate computational thinking? Does the end result somehow resemble a known social phenomenon in some countries? Why?

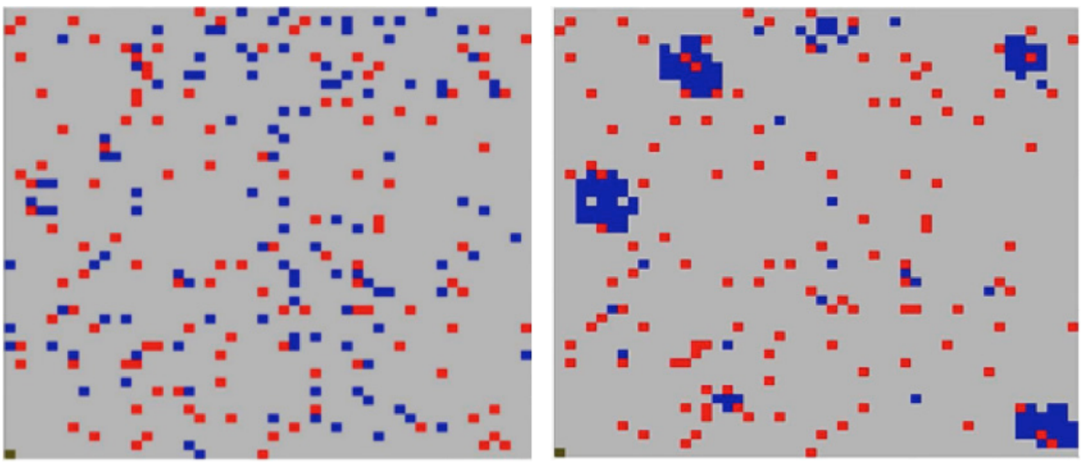

Figure 7: Initial and final stages of the boa d containing blue and red dots

The third context of computational thinking comes from data science and machine learning (ML) (National Academies, 2018). ML has been growing rapidly and transforming an increasing number of industries, ranging from credit risk to medical diagnosis (Reynolds, et al., 1995). This transformation will have a huge impact on the nature of jobs and employment. We need to anticipate the change to avoid the fear expressed by historian, Noah Harari (2018), "The main struggle in the 21st century will be about irrelevance. Many people are being pushed aside." But what is the nature of this transformation? According to Fields Medal-winning mathematician, Cedric Villani (2018, p. 26), "ML techniques mark a break from the classic algorithm. In particular, they mark the gradual transition from programming to learning logic." That led ***Wired*** to prophesise "the end of the code" in June 2016, saying, "In the future, we will no longer programme computers, we will train them." This is a diffe ent kind of computational thinking.

For example, National Academies sees the need to analyse new and greater volumes of information of a wide variety and at a fie ce velocity, which will compound the long-standing challenges presented by data analysis and raise new ones. But we have to consider other critical issues such as biases in ML.

Data is not neutral and so, computers will learn about the stereotypes found within it. That translates to learning sexism or racism should the information fed to machines contain biases. Important ethical issues about using data and privacy should also be considered, along with their consequences.

And given the huge impact of automating tasks, Villani (2018) views a historical opportunity to de-automate human labour when he stated, "Indeed, the automation of tasks and trades can constitute a historical chance to de-automatise human labour. It will allow us to develop human capacities (i.e., creativity, manual dexterity, abstract reasoning, and problem solving). We have to use AI to develop our capabilities since we have the opportunity."

Imagine you were asked to find out what is inside each box in a set. You find that a box contains either a white or black rabbit. You are then told that the boxes were filled following certain criteria that you are not allowed to know. To guess the rule, you can measure the length, width, and depth of each box. You can also consider its colour. Given that, you are asked to guess the colour of the rabbit inside the new box placed in front of you. If you do not hazard a guess, you earn one point. If you guess the right colour, you earn two points. If your answer is incorrect, you do not earn any point.

Figure 8: A student trying to guess the colour of the rabbit inside the box

You were also given the option to make a guess using a rule such as:

IF
Length + 2.5 x width > 3
THEN
Colour = white
ELSE
Colour = black

If you decide to use a rule, you must apply it to the box you have been ask to open. If you get the answer right, you earn four points. If you give the wrong colour, you lose four points. Figure 9 shows how hundreds of students scored in an experiment (Araya, et al., 2014).

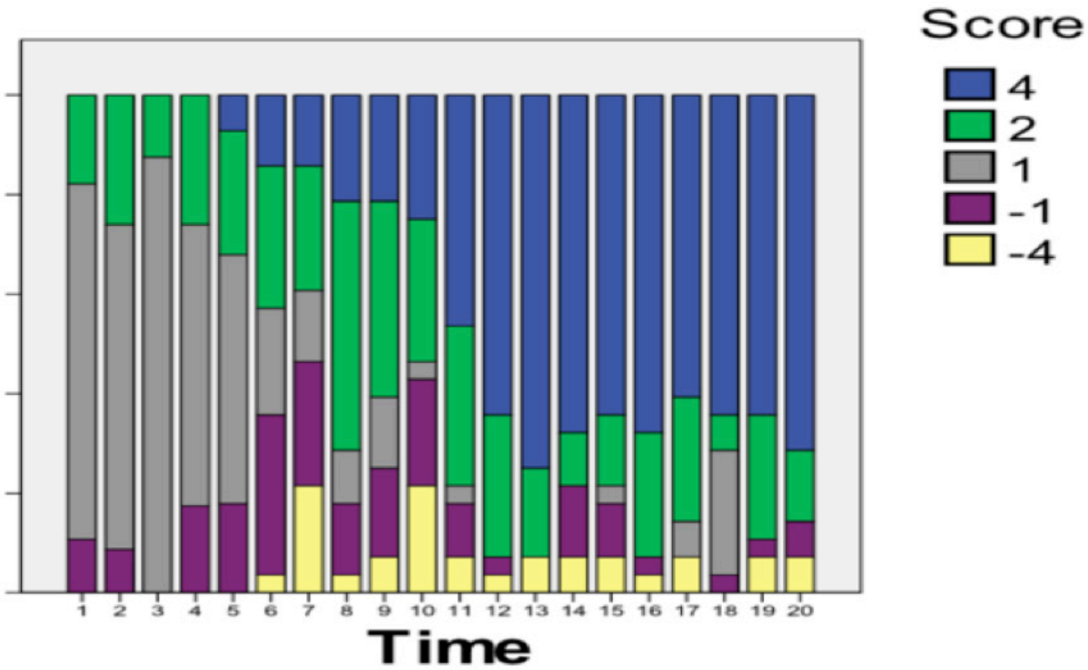

Figure 9: Experiment results for seventh and eighth graders that guessed using a rule

For each of the 20 guesses, every student can gain a score of 4 (i.e., giving the correct answer using a rule), 2 (i.e., making a correct guess without using a rule), -1 (i.e., deviating by guessing "gray"), or -4 (i.e., giving the wrong answer using a rule).

The exemplar shows that ML can be aligned with a curriculum where plotting, equations, and inequations play a central role. Moreover, it can be used to introduce decision trees and basic neural networks (Araya, et al., 1992 and Reynolds, et al., 1995).

Now, consider that instead of a box, you are given a truck engine that either malfunctions or not. You can then look at the viscosity and presence of diffe ent chemicals in the engine oil. Your guesses now have to do with the health of the truck engine (Araya, et al., 1989). How do you build a system that diagnoses the state of the engine? Will a pattern-finding algorithm like the one used with the rabbits inside boxes work? Will this require a diffe ent kind of computational thinking?

These three pillars of computational thinking reveal the importance of two key values—understanding and objectivity. Deep understanding requires powerful tools, such as a microscope or telescope to enhance human vision. Similarly, a computer enhances human reasoning and brings objectivity. It forces you to make assumptions explicit since it cannot read your mind. But with its help, you can compute the consequences of your assumptions like everyone else. Others can also carefully inspect your models and logic. They can read, run, search for bugs in, and debug your algorithms. That could be an effective cure for typical reasoning errors, such as the illusion of explanatory depth (Sloman, 2017), confirmation biases (Mercier, 2017), and undesirable values like the tragedy of the commons (Pinker, 2018), where behaviours that seem rational for an individual becomes self-defeating when viewed collectively.

According to philosopher, Daniel Dennett (2017), we are Popperian creatures with a penchant for permanently creating forward-looking models and using them to make decisions. But we need not understand this process. Only with thinking tools, such as those used in computational thinking, can we do systematic explorations and attempt higher-order control of mental searches.

Computational thinking is much more than programming. According to Tedre and Denning (2016), "Computational thinking initiatives that focus solely on programming tools and techniques market a tasteless and scentless view of computing that emphasises an analytical abstract world far distant from the hands-on dirty complexities of the real world. In the early stages of the computer revolution, the focus on calculation may have justified a programming-and-techniques view but since the 1980s, the revolution produced radical changes in the way we see the world and move in it" (p. 125). Moreover, computational thinking lessons need not be done with computers. All of the exemplars described in this article showed that. Even programming lessons can be done unplugged or without computers (Faber, 2017). On the other extreme, some of the proposed exemplars can be implemented as online synchronised games played simultaneously by thousands of students (Araya, et al., 2014 and 2016).

Can We All Learn Computational Thinking?

In a super smart society, a computer takes a central role. Computing will become ubiquitous. Moreover, it will actively interact with citizens and other devices on the network. This is a completely new phenomenon, where machines are autonomous and take initiative. To understand this situation, citizens need to adopt the strategies and knowledge of successful early adopters. Computer scientists and computer engineers tell us that computational thinking is the key. It is essential for developing creative human capital that can adapt to the challenges of the 21st century.

In the end, computational thinking processes are just strategies for successful reasoning. They include powerful strategies, such as discretising, decomposing, modularising, factoring, and forward and backward chaining reasoning. They also espouse fundamental concepts, such as lists, arrays, iterations, recursions, states, pseudo-codes, data, and data mining. These will all lead to a richer and deeper backbone to support reasoning. The ability to iterate, simulate, operate, perform, and debug algorithms will pave the way for efficientl building computational models and solving real-world problems. Pattern detection is also critical.

Does this kind of reasoning differ from mathematical thinking (Isoda and Katagiri, 2012)? Computational thinking works with mathematical and statistical thinking (Araya, et al., 1992 and González, et al., 2019), which lie behind ML. Given the enormous quantity of applications and their impact on voice and visual recognition and autonomous vehicles, students need to understand the central ideas of ML. But computational thinking is not only useful in solving technical problems. It is also helpful in general reasoning. It can help people with arguments and deliberations, especially in terms of detecting usual reasoning errors, such as causal attribution and confirmation biases

Transitioning to a super smart society will bring on enormous challenges and anxieties, including in education. We are starting to see the less-educated rebel against the more educated (Collier, 2018). AI is automating repetitive tasks, leaving jobs only for those capable of accomplishing more complex tasks and working with machines. These tasks require more knowledge and skills and many people are getting left behind. As such, we need to start teaching computational thinking to young kids.

In the 11th century, only 2% of the male population in the West was fully literate (Morris, 2015). Practically none of the females were. For an ordinary citizen of that era, learning to read and write was probably considered a very complex endeavour that not everyone can do. But today, we all learn how to read and write. This time, we need to teach everyone computational thinking.

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Transforming Modern Society and Teacher Training to Develop Creative Teachers

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Abstract

The Fourth Industrial Revolution is known as "Society 5.0" in Japan. As industrial structures change, work also changes and so do the necessary capabilities of workers. If those capabilities are changing, then the things we should be teaching in school should also change. With the emergence of AI, teachers need to be more like coaches and become creative. A creative teacher foresees the future. He/She demonstrates pliancy and responsiveness to develop children's potentials; gather resources; develop or acquire colleagues' new viewpoints; and become a specialist who creates a comfortable learning environment for lessons, classroom management, and school events. Using AI is important to do that. However, teachers can also become creative if they act within a fundamental human rights principle and develop class lessons that are comfortable and use their intuition to facilitate students' learning experiences.

Keywords: AI, Society 5.0, creative teacher

Transformation of the Society and the Path for Education

Future forecasts and educational training are closely connected. It can be said that future forecasts and societal debates are fundamental parts of education for teachers. That is because children will become working adults in the future. First graders in 2018 will become adults in 2032. They will turn 30 in 2042 and 40 in 2052. Even after 2050, they will become the backbone of the society. What sort of society will we have in 10, 20, or 30 years? It is necessary to forecast the future as much as possible and teach people about the corresponding knowledge that will be required. From an educational policy perspective, of course, we must think about what teachers should be learning to develop individual ideas about the future of the society and how to teach students.

In an age of comparatively slow societal change, we may be able to teach as we always did in the past and manage without any real future forecasts. But as we have seen with the evolution of the smartphone in the 2010s, society is changing rapidly.

Today, Virtual Reality (VR) and augmented reality (AR) are said to be the next-generation platforms. University students have started showing interest in AI, VR, and AR. These have become hot topics. And these trends are tied to the advent of the Fourth Industrial Revolution.

The First Industrial Revolution began at the end of the 18th century when hydraulic power and the steam engine mechanised factories (England, etc.). The Second Industrial Revolution happened at the beginning of the 20th century, when electric power (i.e., internal combustion engines and electric motors) brought about mass manufacturing (U.S., etc.). The Third Industrial Revolution began in the 1970s, when electronic engineering and information technology (IT) brought about precision and high-performance electrical equipment and the automated production of automobiles (Japan, etc.). The Fourth Industrial Revolution is known as "Society 5.0" in Japan.

As industrial structures change, work also changes and so do the necessary capabilities of workers. If those capabilities are changing, then the things we should be teaching in school should also change. Children will change because of the influences of the society and teachers need new devices to reach them. In short, the Fourth Industrial Revolution and educational reform are related.

At present, this affects all countries in the same way. However, Japan faces additional serious problems, such as a shrinking birthrate, a decreasing population, a shrinking market, an unprecedented aging of its society, a shortage in caregivers, and large fiscal deficits. Aging societies are common in China and Europe but Japan's case is outstanding. As aging of the society ramps up, its social welfare-related budget increases and people worry that the money for education might decrease. Some Japanese are concerned that we are slipping behind due to the Galapagos effect, which is affecting our place in the global economy. The Galapagos effect is used to describe Japan's unique culture of technology that has not expanded beyond its borders in the same way that the Galapagos Islands exemplify unique evolutionary developments in nature.

Japan has always been an "education nation." We need to continue to nurture education and scholarship. If we do not reform education and improve teachers' professional capabilities, we may be left behind in the Fourth Industrial Revolution. We cannot forget that the quality of school education and teacher training is ultimately supported by academic research. Education and research provide the foundation for the Fourth Industrial Revolution. Is educational reform necessary to create prospects for the future society?

First, I would like to explain my thinking process about the issues I just described.

- After the Fourth Industrial Revolution, human beings' central activity will be inquiry, which is the source of identity and self-effica . We will become tolerant of diversity and our symbiotic relationship with others will be respected. This sort of society is called a "harmonious and inquisitive society." And this makes it the task of education to train symbiotic qualities and the ability to inquire or conduct research.

- For a harmonious and inquisitive society, we need creative teachers. We need to redefine a teacher's professionalism as the core a creative practice.

- It will become important to have a philosophy of symbiosis and inquiry when training teachers at the university level.

This paper seeks to examine how creative teachers should be in a new era or Society 5.0. To achieve this purpose, I set out to answer the following research questions:

- How will society change and how should education and teachers change with it? As AI advances, teachers must change. If we do not change, our profession will not survive. Of course, some things are immutable.

- What are the immutable parts of being a teacher? And what makes a creative teacher? To realise this, what sort of training is necessary?

The answers to these questions are discussed in the next sections.

The Development of AI and Work

It is said that Japan's future will be characterised by a decreasing population and an aging society. By 2030, people who are 65 and older will make up 36.1% of the country's population (Terada, et al., 2017, p. 16). At the same time, it will suffer f om a serious labour shortage.

In China, due to its aging population, the working-age population is in decline. And it has been pointed out that by 2025, its population will begin to decline as well (Terada, et al., 2017, p. 62). The same trend can be seen in the Southeast Asian region although diffe ences were seen by country.

It is said that demographic changes will lead to the Fourth Industrial Revolution in the 2020s. Further development of AI and robots is predicted. It has been forecast that the development of AI "is highly expected to end up replacing about 49% of Japan's working population with technological AI and robots" (Terada, et al., 2017, p. 96).

As such, how will the quality of work change? As AI takes center stage, new work related to it will be born. It may be enough for people to find specialised work in the fields that support AI. They could share and collaborate with AI.

For example, doctors have begun collaborating with AI systems at the University of Tokyo and Jichi Medical University. An enormous amount of medical literature on AI is now available for diagnosing illnesses through images and setting up treatments based on those diagnoses. Final judgements are still done by doctors, of course. If this process advances, a doctor will not lose his/her job but his/her identity and status may change.

What Will Become of Teachers?

In this kind of discussion, it is important to think about what type of AI will advance and to what degree. AI is of two types—specialised and general. The AI that doctors use is specialised. A famous example of this type is computerised shogi (i.e., Japanese chess) playing and Google's search algorithms. These have strengths in specific fields. But general AI systems are now being developed. Even these cannot acquire specialised knowledge by completing tasks in a certain field. Put in pedagogical terms, there is no formal discipline (i.e., thinking power and transfer of learning). However, there is one form of high-performance general AI that is under development so it can transfer knowledge on its own. It works similar to how the human brain handles formal disciplines so when it takes on work in a diffe ent field, it ma es educated guesses.

When we look at all the information related to the development of the Fourth Industrial Revolution, the most often heard conclusion is that teachers will not be replaced by AI (***The Economist***, 2017, p. 311). AI researcher, Maki Sakamoto (2017, p. 39), wrote, "The weakness of AI lies in work that requires high capabilities or so-called 'deep-responsibility work,'" such as that of a doctor or an elementary schoolteacher. The argument that AI will never become a teacher generally states that AI can only adhere to a specialised field. It can support a teacher but a human who can gauge the reactions of children and understand them emotionally will still be needed.

So how will the quality of a teacher's work change as specialised or first-gene ation general AI spreads? This question is connected to how a teacher's professionalism will be redefined

AI researcher, Yutaka Matsuo (2015, p. 51), predicts that AI will enter the education field deeply around 2030. If that is true, the relationship between AI and teachers should be debated in education research.

Famous big data players, such as Recruit, Microsoft, Pearson, and IBM, have already entered the business of education. Strategies can be devised for measures and countermeasures related to group learning by grade and school through access to a database. In the U.K. and Australia, schools have large discretionary budgets that they use to hire private education consultants (e.g., former principals who put up their own businesses) for proposals and analyses. The principal needs to use the consultant's knowledge and data and exercise leadership.

What will the teacher's work be? I would like you to envision teachers teaching students in various classrooms and overseeing a homeroom. Each student has his/her own individuality and their guardians probably hold a variety of opinions. Their feelings also change from day to day. Teachers must read the students' expressions, understand them, form a trusting bond with them, and teach them. However, the students are children and they are not always in touch with their emotions. Human relations in the classroom have many variables. From a group perspective, the classroom teacher needs to be observant. I do not think AI can handle that sort of work.

However, beyond the compulsory education that is so important to maintain lies the structure of the society and building human relationships, high school classes may have spread to online classrooms. Will that reduce the number of teachers? It may be necessary for teachers and AI to share. But is the idea of sharing enough?

AI researcher, Noriyuki Yanagawa and team, posit, "If you think of education in a straightforward way, AI or robots cannot keep up. Human strength lies in our pliable ability to handle problems with many individual variables. Tools and education that further those strengths will become even more necessary" (Yanagawa, et al., 2016, p.9). The pliable ability to handle problems with many individual variables is creative. For teachers to be able to teach symbiosis and inquisitiveness as the Fourth Industrial Revolution unfolds, they will need to be creative.

The New Teacher: The Creative Teacher

According to ***The Economist*** (2017, p. 317), "In the long term, the market for medical, education, and legal affairs will expand along with employment opportunities. Monotonous work that no one wants to do like making algorithms will be taken up, and the quality of people's employment will trend in a positive direction."

"Education may become quickly customised to each individual's need for material and instruction" (***The Economist***, 2017, p. 316). However, at the same time, "If the students are put to sleep by a monotonous and meandering lecture, the teachers will just end up getting fi ed. Teachers should be like sports coaches… and help students who fail. We can expect a sense of balance to be exerted" (p. 312).

With the emergence of AI, teachers need to be more coach-like. We will see fewer teachers who have exclusive knowledge that they impart from above (i.e., traditional teachers). So what will the new teachers be like? In simple terms, they will be "creative teachers."

A creative teacher foresees the future; has the pliancy and responsiveness to develop children's potentials as much as possible; can gather resources and develop or acquire colleagues' new viewpoints; and is a specialist who creates a comfortable learning environment for lessons, classroom management, school events, and more.

When we speak of being creative, we are not talking about designers or scientists. Teachers do not have to force uniqueness or originality. Instead, they need the ability to see the children's actual situation and understand and analyse changes, varieties, societal features (e.g., change in play, friendships, and communication), and family environments. They will then shape the classroom experience and lessons to encourage each child to grow into an adult who can enjoy a comfortable life. In this process, the questions will become: How much originality and ingenuity should the teachers show? How pliant should they be? How much time should they give children to develop? Can they talk to and help children on their own? A teacher can become creative if he/she acts according to fundamental human rights. He/She should make class lessons comfortable and use intuition to structure students' experiences.

Based on the basic ideas I mentioned, the qualities of a creative teacher or the core professionalism of a teacher in the Fourth Industrial Revolution are:

- The teacher should use AI to support individual learning and advance collaborative learning. The three elements of school management are said to be people, things, and money, but we have reached an age where time and AI should be added, turning these into five elements of school management. In other words, the teacher should use AI to ease work and teach others to use the technology to create high-quality class lessons.

- The teacher should consider the children's and their guardians' ideas, books, educational materials, regional educational resources, and global topics to develop and put into action a curriculum that stresses symbiosis and inquiry. To do this, they need a wide range of knowledge and training to gain analytical and problem-solving skills, a strong structure, good planning skills, and an imagination. This kind of research ability can be acquired by writing a graduate school thesis. Research is a rich source of creativity. In other words, teachers need practical research skills.

- Teachers should not just rely on AI. They should think about what AI cannot do as well. AI cannot cooperate, negotiate, or network with others; support a child (e.g., helping a child expand his/her narrow horizon or face difficultie related to physical development); meaningfully change curriculum direction to reflect the environment and various contexts; and motivate, encourage, and build a child's confidence (e.g., inspire, influence, encourage, fi e up, and help feel alive and vital). These are a teacher's work.

- "People can find themselves in an unprecedented situation but they can also apply past experiences to a diffe ent field and extend and apply their knowledge to solve a current problem" (Sakamoto, 2017, p. 39). Abilities unique to humans include "implicit understanding" and "being able to refine communication to suit diffe ent groups and exert leadership." These abilities will continue to be important for teachers as they are now.

- Do not fear or be anxious about AI. To avoid fear and anxiety, humans have developed an aesthetic sense to remain calm (Habu, 2017, pp. 39–41, 80–83, and 97–98). When seeking an aesthetic sense, a feeling of tension and seriousness intersect. Also, an aesthetic sense can impress people through athletic competitions, artwork, singing, and other activities. A teacher needs an aesthetic sense as he/she teaches and manages classes. This will make classes and events more impressive. However, to avoid being authoritarian or prescriptive, remember that our aesthetic sense is not immutable.

- A teacher must grasp a student's needs while also creating new needs by developing an attractive curriculum. AI can be useful in this process because of its expanded intelligence. The essence of a creative teacher is to create high-quality curricula and lessons. It is desirable to apply the approach or educational method to symbiosis and inquiry in a pliant and variable way, reflectin on the context of the school and the conditions of the class or child. An effective means of protecting quality is through lesson study. In lesson studies, the class observer does not offe one-sided opinions. If there is criticism, there should be practical advice on how to change. When criticising a certain aspect, the observer should put himself/herself in the teacher's shoes and think about what he/she would do in a similar situation. He/She should ask questions like "What sort of question would I pose to get the child to speak further?" Through this detailed vision, the observer can put forth more ideas for the teacher. It is safe to say that this sort of lesson study is a creative activity for teachers.

- The advent of the Fourth Industrial Revolution means our society will be structured based on our actual world. It will be a mix of the real and virtual worlds. If a school or teacher uses virtual materials and AI, he/she should keep one foot in the real world, reiterate ethics, and support the children's societal and realistic development.

Current Teacher Training: The Case of the University of Tsukuba

To develop new teacher characteristics in universities and graduate schools, we need ideas on using inquiry as an axis for developing and using knowledge. I will offer o e detailed example.

Since April 2017, the Master Programme in Education at the University of Tsukuba has been offering an international baccalaureate degree through an accredited programme. It is called "Master of Arts in Education, International Education Programme." It aims to develop internationally minded inquirers with a sound understanding of innovative thinking in education and the skills necessary to plan and conduct research on issues in international education. Students will investigate pedagogies, curricula, and assessment methods in the context of the international baccalaureate and other international curricula.

"This specialisation welcomes open-minded thinkers with an active interest in educational innovation who want to make a contribution to the field of international education" (University of Tsukuba, 2017, paragraph 4). Obtainable certifica es include the International Baccalaureate Certifica e in Teaching and Learning (IBCTL, PYP/MYP/DP) and the International Baccalaureate Advanced Certifica e in Teaching and Learning Research (IBACTLR).

The required courses for the IBCTL are "Pedagogy for a Changing World II," "Assessment for Learning I," "Assessment for Learning II," "Curriculum as Process I," "Curriculum as Process II," "International Baccalaureate Primary Years Programme," "International Baccalaureate Middle-Year Programme," "International Baccalaureate Diploma Programme," and "Professional Learning and Reflective Practice." There are many other subjects to choose from and a master's thesis is also required.

Associate Professor Akiko Taira who has had some outstanding experience in teaching at an international school in Hawaii introduced mindfulness and discussions of a person's identity as seen through cultural and societal lenses known as "Curriculum as Process II." Its class plan includes "Topic 1—Overview and Review of Curriculum as Process I," "Topic 2—Planning Processes," "Topic 3—Planning for Trans- and Inter-Disciplinary Learning," "Topic 4—Experiential Learning," "Topic 5—Planning for Inter-Disciplinary, Trans-Disciplinary, or Experiential Learning," "Topic 6—Collaborative Planning and Reflection " and "Topic 7—Curriculum Mapping: Accountability and Communication."

One piece of educational material is called "Shadow a Student Challenge." Students are asked questions such as:

- What would the school leaders see in your country's average school if they shadowed a student? Think in groups of three or pair up.

- In your ideal or dream school, what would you see if you shadowed a student? Think, pair up or form groups of three, and share.

Through these questions, students may see schools in a new light. They also introduce questions such as:

- What do we want the students to understand? (Concepts)

- What do we want students to be able to do? (Skills)

- What do we want students to learn about? (Knowledge)

- What do we want students to feel, value, and demonstrate? (Attitudes)

- How do we want students to act? (Actions)

These introduce the five principles of the IB TL PYP curriculum.

Normally, the method for introducing and expanding the principles of a curriculum happens during teacher training lectures. But in this class, the principles are not taught first; they are acquired through inquiry and arrived at last through a process.

"With humanism as basis, we respect symbiosis and inquiry," Akiko Taira told me when we spoke on 17 January 2019. "To conduct human-centric teacher training, we put information and communication technology (ICT) to work. As the Fourth Industrial Revolution progresses, humanity's and students' feelings of accomplishment become important. The International Baccalaureate Programme is moving towards this direction, too."

The International Baccalaureate Teacher Training Programme at the graduate school of the University of Tsukuba is cooperating with schools. In the future, the university will work with the Senior High School at Sakado, a University of Tsukuba affili e that employs the Diploma Programme. Moreover, on 11 December 2018, the university signed a partnership agreement with the Saitama City Board of Education. The main objective is to cooperate with the Omiya International Secondary School that will open in April 2019. Through this cooperation, a mutual exchange between the school (i.e., lessons) and the university (i.e., research) will take place and the quality of lessons and academic research is expected to improve.

Omiya International Secondary School has organised a consistent six-year middle school curriculum. For four years, students learn using the International Baccalaureate Middle-Year Programme. Fifth-year students, which are equivalent to second-year senior high school students, and sixth-year students, which are third-year senior high school students can choose from among three paths—the global course (International Baccalaureate Diploma Programme), liberal arts, and STEM. Saturday morning is called "Learner-Directed Time." One unit a week is spent on English Inquiry while another is spent on the Grit, Growth, Global (3G) Project.

The graduate school of the University of Tsukuba cooperates with more than just the Omiya International Secondary School. As our effo ts progress by using IT, we can respond to the Fourth Industrial Revolution through creative and inquisitive ideas and tolerance for symbiotic minds. This is the teacher training for a new era and one example of an innovative teacher training curriculum. Spreading this effo t is connected to creative educational training and contributes to the realisation of a comfortable learning environment for students.

Because of the Fourth Industrial Revolution, humanity becomes more important than ever for our society. Inquiry is the core activity of human beings. At the same time, we need to become tolerant of diversity and respect symbiosis. To create this symbiotic and inquisitive society, we need creative teachers. To activate the training of creative teachers, we will need to exert even more effo t and use tools.

Note

This article is a revised English edition of "Become a Creative Teacher" published in Japanese in 2018 (Tokyo: Gakubunsya), which was edited by Hiroshi Sato. It is a revised version of Sato's chapter, which was presented as a keynote speech at the SEAMEO-University of Tsukuba Symposium VII (Tokyo) held on 10 February 2019.

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Competency and Capability Development for Science Teacher Training in Japan

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Abstract

Science teachers in Japan are working to form and improve their competencies and capabilities through the multi-layered expansion of teacher training. This article provides an overview of the institutional framework for science teacher training in Japan, gives a representative example of science lesson study and the teacher license renewal system, and reveals a concrete image of science teacher training.

Keywords: Science teacher, teacher training, lesson study

Introduction

What competencies do teachers need? When Japan's teachers are asked this question, they are likely to give diverse answers—excel in teaching lessons, lead children and students, excel in classroom management, and so on. It goes without saying then that to help teachers attain the competencies they need, going through training stages alone will not complete their education. Rather, the only way to formally improve them is through extended lesson practice, continuing in the profession for a long time, and accumulating wisdom through constant study. As the phrase "establishing the image of a constantly learning teacher" (Central Council for Education, 2012) expresses, teachers require lifelong professional learning to grow into their specialties and acquire passion to respond to the various needs of a changing era and society.

Teacher training plays a vital role in this process. Japan's in-service teacher training has established several training opportunities, including those for science teachers. Teachers who take part in the training work to form and improve their competencies and capabilities.

This article draws attention to how science teachers expanded opportunities for training to improve their competencies and capabilities. It provides an overview of the institutional framework, presents several representative examples, and hopes to offer a conc ete image of science teacher training.

Competencies Required of Science Teachers

As we mentioned in the beginning, when we talk about the competencies of science teachers, they can cover a multitude of topics. Ohtaka (2008, p. 26) mentions the difficult of limiting those competencies but for convenience's sake, he breaks them down into the following five ca egories:

1. **Pedagogical principle competency:** Principle for education, a sense of mission as a teacher, passion, and so on.

2. **Basic practice competency:** Basic competency to conduct educational practices as an independent teacher.

3. **Skillful practice competency:** Competency to conduct advanced educational practices as an experienced teacher.

4. **Pedagogical research competency:** Competency to conduct research directly targeting themes of educational reality (e.g., research on effective eaching and learning strategies, etc.).

5. **Pure science research competency:** Competency to conduct research on professional themes taught in lessons.

These competencies seem closely related to the categories of the knowledge base for teaching showed by Shulman (1987, p. 8). If any of these competencies are missing, it is difficul to expect a hoped-for outcome in science lessons. For example, no matter how much knowledge and skills a teacher possesses about natural science applicable to the classroom (competency 5), if the ability to create a lesson plan and execute it in front of students (competencies 2 and 3) are lacking, good educational results will not be produced. Therefore, competency in each category must be balanced well for the potential for improvement. If a science teacher then uses teacher training to further his/her specialisation, it can be said that this is the diffe ence between success and failure.

However, it is not always true that just because a teacher participates in diffe ent training, he/she can thoroughly improve in all five competency categories. It is possible for training to cover all competencies but the aims and stance of typical training will correspond to the person in training and may place diffe ent weights on diffe ent competencies. For example, for a teacher in his/her first year on the job, beginner training would probably focus on improving competencies 1 and 2. On the other hand, training targeting veteran teachers or teachers in management positions would not make those same categories a priority.

Given these assumptions, a teacher facing training would first need to reflect on his/her own lessons then grasp the formation of competencies from a meta point of view. Also, from the viewpoint of that teacher's career, by choosing certain training to participate in, the teacher has a better chance of growing professionally.

Institutional Framework for Science Teacher Training

Teacher training in Japan has expanded in multiple ways via responsible organisations and target trainees categorised by life stage (e.g., duration of service or job function), embodiment, and implemented content. Moreover, while we cannot get into the comprehensive details of each type of training, the published ***Teacher Training Guide 2018*** of the National Institute for School Teachers and Staff Development (NISTSD) provides a foundation that gives an overview of the institutional framework for teacher training, including for science teachers.

According to the ***Teacher Training Guide 2018*** shown in Figure 10, training occurs mainly from the viewpoint of the place where lessons are implemented and split into three big categories—self-training, in-school training, and out-of-school training (NISTSD, 2018, pp. 2–3).

- **Self-training:** This refers to autonomous training based on one's awareness of the personal challenges of individual teachers. An example for science teachers would be repeating daily lessons, researching teaching materials, studying science-related journals and literature, participating in diffe ent science and research groups or circles, and many others.

- **In-school training:** This involves finding solutions to schoolwork and research related to planning and organising for all teachers. They are categorised as specially established collective training in school and training for daily school affairs or so-called "on-the-job training (OJT)." As far as implementation goes, more than a few schools have research departments or personnel who are in charge of training structure improvement based on grade or subject.

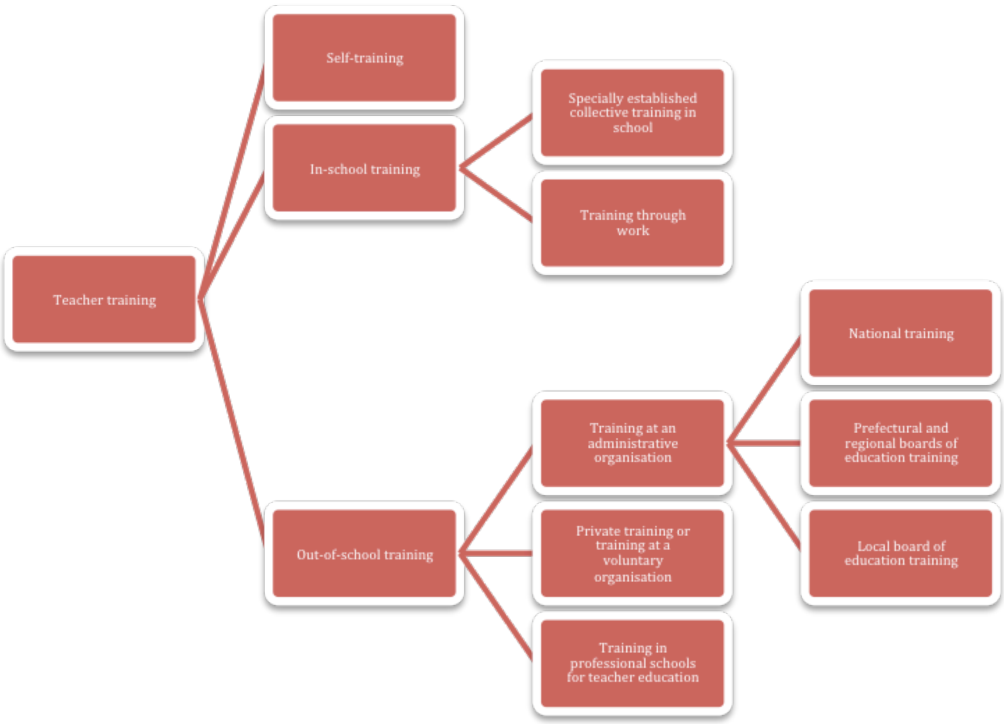

Figure 10: Types of teacher training in Japan (NISTSD, 2018, p. 3)

One of the core pillars of training is lesson study. We will discuss this in more detail later but a lesson demonstration of a science class is typically planned and executed around the main research themes established by the school then feedback is offe ed. This is sometimes done only in school with an intra-school study conference that administrators and other teachers attend. It is also sometimes done with people from outside the school forming a public study conference.

- **Out-of-school training:** As the name implies, this training takes place away from the school or in the field. It is divided in o the following three categories:

  - **Training through an educational administration organisation:** This is also called "administrative training" and is often held by a national, prefectural, or local board of education. There are many diffe ent types. Looking at a prefectural-level board of education training session, for example, there are legal training for beginners or 10-year veterans, teacher training for trainees with five or 20 years of experience, student leadership training based on job evaluation, principal and vice principal training, and many other kinds of established training programmes. Of course, within this training regimen are sessions for science. Oyama, et al. (2014) surveyed all of the science-related training offe ed in Japan by the prefectural board of education in fiscal 2012. The results show that about 96% of the training focused on observation and experimentation while around 79% touched on science-related teaching materials and tools. These are the two main science-related training topics.

  - **Private sector training or training at a volunteer organisation:** Training for science, like other subjects, is held by an associated educational group. One example is the collaboration between Toho University and the Chemical Society of Japan, which resulted in the Chemistry Experiment Workshop. This training aims to improve practical science teaching and lesson-making skills. It also features some corporate social responsibility (CSR) activities through a company that makes science teaching materials, a practical training group for safe science experiments, and cases where a company forms a practical training group using its own educational materials.

  - **Training in professional schools for teacher education:** A professional school for teacher education offers high-level specialised training in a professional graduate school setting. This type of training was formed in 2008. In this training, more practical leadership and development activities are offe ed, with an influential part dedicated to teacher training for building a new education style. For regional school teachers (i.e., core mid-career teachers) looking to take on leadership roles, indispensable teaching theories and very practical and applicable training sessions help enhance leadership skills. When it comes to in-service teacher training, this is especially important. The point is to develop high-level practical leadership skills through taking common subjects/electives and participation in school training.

Also, while not shown in Figure 10, the teacher license renewal system established in 2009 had a wide impact on teacher training. Under this system, teacher certifications lasted 10 years. When renewal comes, another 30 hours of further license training is required. The new requirement is held at universities accredited by the Minister of Culture, Sports, Science, and Technology (MEXT). There are quite a few options for science-related training within these courses.

That completes the outline of the institutional framework for teacher training. Of course, the presentation we gave here and the training sectors we highlighted are just examples. Some training does not fit into any one category. For example, we mentioned beginners' training, which in addition to being held at prefectural education centres, also comes with a requirement of 300 hours of in-school training, making it a combination of out-of- and in-school training. At any rate, we would like to make it clear that there are many types of teacher training sessions available in Japan.

A Concrete Image of Science Teacher Training

Many organisations have been established to further training for science teachers and teachers of other subjects. But what are the detailed contents and paths of progress for such training? Here, we would like to focus on the science lesson study and the teacher license renewal system implemented for science teachers almost 10 years ago.

Science Lesson Study

Japan's lesson study is spreading around the world and attracting a lot of attention (National Association for the Study of Educational Methods, 2009, p. i). Among Japanese teachers, there is no doubt that everyone is familiar with these activities. Lesson study conferences hold many training sessions both within and outside schools.

Figure 11 outlines the basic structure of a science lesson study conference (Isozaki, 2014, pp. 27–29 and Ohtaka, 2012, pp. 6–7). Let us take a closer look.

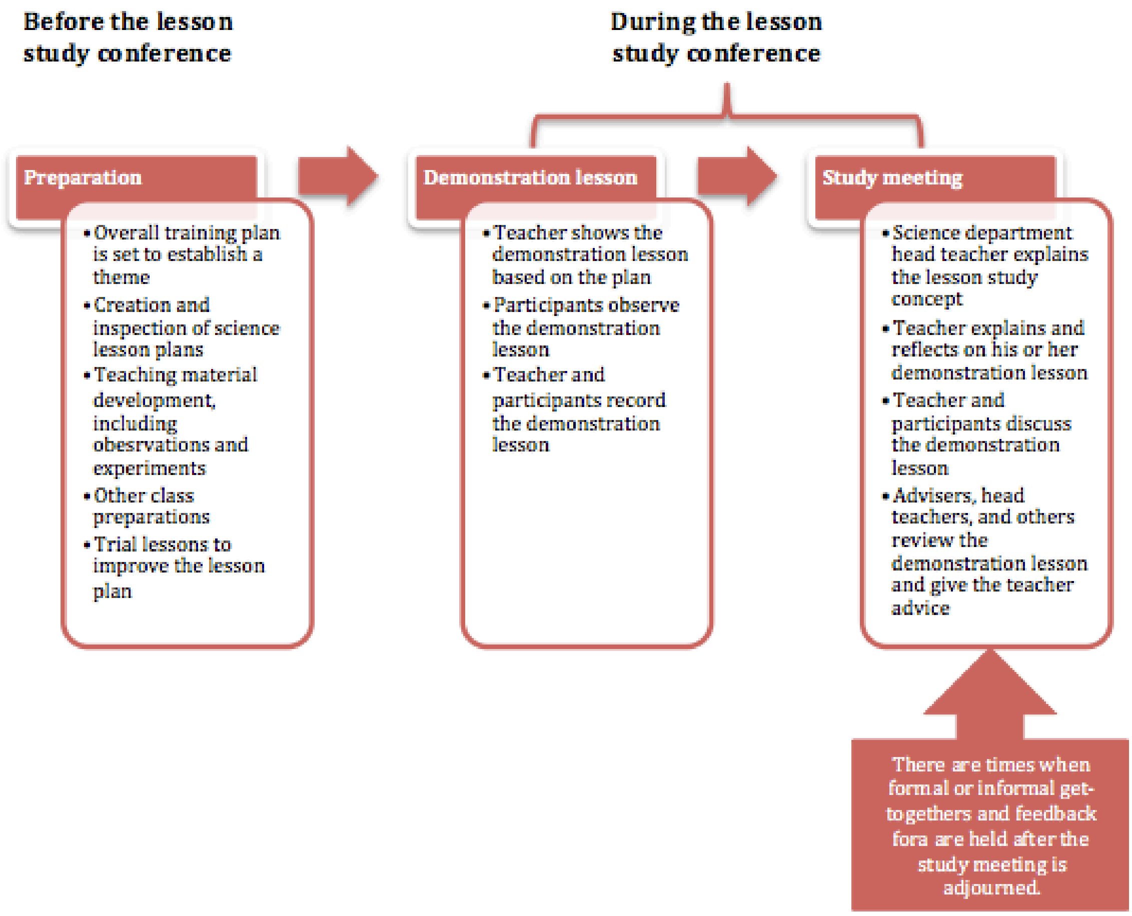

Figure 11: Basic structure of a science lesson study conference (Isozaki, 2014, pp. 27–29 and Ohtaka, 2012, pp. 6–7)

First, during the preparation stage for a lesson study conference, based on the main subjects of the entire school and the research theme set for each subject, the teacher facilitates the discussion to design and review the science lesson plan. In the lesson plan, the goals of the entire unit; the lesson position within it; the teaching materials to use; the learning situation of the students in the classroom; the subject; the students' answers and expectations; detailed learning activities, including viewpoints and experiences; ways for the teacher to assist and support students; and viewpoints and methods for evaluating student learning must be carefully written down. At the same time, the teaching materials should be developed, including observation activities and experiments. Participants in a lesson study are very interested in what sort of teaching materials will be used and what observation activities and experiments will be done, which give the teacher a chance to show off his/her skills. Furthermore, it is not uncommon at this stage for other teachers or external university professors and consultants to offer advice. Teachers also use other classes as trials for improving their lesson plans.

In a lesson study conference at an external location, there are also cases where before the lesson study, effo ts are exerted to explain the overall training subjects of the school in a "plenary session." All participants are given copies of the lesson plan before they observe the demonstration. Participants may examine how the written contents of the lesson plan align with the actual developments in class. Sometimes, fellow teachers or the teacher may record the class so it can be re-shown during the study meeting.

When the demonstration lesson is over, the teacher and participants continue to get together for the study meeting. In it, the head teacher of the science department will explain the concept of the lesson study. Then the teacher explains his/her aims and points of emphasis for the class. Afterwards, a meeting is held with the participants. How the meeting proceeds varies per case. The participants and teacher have an open discussion and exchange opinions at times or they break up into small groups to go over the teaching materials and class observations. After that, a representative from each group presents the findings o everyone.

Finally, an adviser (e.g., a university professor, a consultant, or an administrator) evaluates and offers advice. Sometimes, formal or informal gatherings and get-togethers after the study meeting are held to continue the critique. These occurrences may include information exchange and discussions beyond the framework of the lesson study. However, in recent years, we have seen a decline in these get-togethers.

We have certainly seen problems with these types of science lesson studies, particularly when discussions were weak (Ohtaka, 2012, p. 8). But it is fair to say that they have been indispensable in forming and improving science teachers' structural and practical competencies.

How Science Teachers Train for the Teacher License Renewal System

As mentioned earlier, the teacher license renewal system is relatively new, although it has been in use for more than 10 years now. In 2018, 556 universities, junior colleges, and boards of education across the country were accredited by MEXT. When renewal time arrives, teacher training is divided into required subjects (i.e., six hours or more), elective and required subjects (i.e., six hours or more), and elective subjects (i.e., 18 hours or more). Almost all science-related training sessions fall under the elective category.

What sort of training is actually held and performed? Table 1 compiles one section of the science training sessions held at the University of Tsukuba in 2018. There is a wide variety of training sessions, ranging from how to plan a science class to teaching methods, developing teaching materials, observation activities and experiments in fieldwork, new scientific research, and training sessions for university-affili ed schools. For example, in "Science lessons to cultivate science lovers," a science class is built based on problems that Japanese students face compared with their international counterparts, new ways to teach science, recent educational theories, and learning achievements, which all lead to gaining a deeper structural understanding of science education mainly from the viewpoint of subject-based education.

Training Name	Target									
	Kindergarten	Elementary School	Middle School	Compulsory Education School	High School	Six-Year Secondary School	Special Education School	Certified Centers for Early Childhood Education and Care	Nursing Teacher	Nutrition Teacher
Science lessons to cultivate science lovers	•	•	•	•	•	•	•	•		
Untangling concerns about radiation: Basics of and measuring radiation	•	•	•	•	•	•	•	•	•	•
Lecture on super balls		•	•	•	•	•				
Energy resources and new technologies		•	•	•	•	•				
Technologies that support AI and big data			•			•				
Trick experiments and crafting fun	•	•	•	•	•	•	•	•		

Training Name	Target									
	Kindergarten	Elementary School	Middle School	Compulsory Education School	High School	Six-Year Secondary School	Special Education School	Certified Centers for Early Childhood Education and Care	Nursing Teacher	Nutrition Teacher
Discovering the Mt. Tsukuba Area Geopark	•	•	•	•	•	•				
A tale of rice and rice plant	•	•	•	•	•	•	•			•
Changing Earth: Earthquakes, tsunamis, volcanic eruptions, and landslides		•	•	•	•	•	•			
The Satoyama Expedition	•	•	•	•	•	•	•	•		
Planting strong and tasty vegetables: Experience-based learning at the Institute for Horticultural Plant Breeding	•	•	•		•	•	•	•		

Training Name	Target									
	Kindergarten	Elementary School	Middle School	Compulsory Education School	High School	Six-Year Secondary School	Special Education School	Certified Centers for Early Childhood Education and Care	Nursing Teacher	Nutrition Teacher
Museum park field observation: Find out the names of common trees, grasses, and mosses	•	•	•	•	•	•	•	•		
The beginning of animal observation for beginners: From water fleas to bears	•	•	•	•	•	•	•	•		
Practical exercise at an affili e elementary school		•	•	•			•			
Practical exercise at an affili e junior high school		•	•	•	•	•	•			
Practical exercise at an affili e high school			•	•		•	•			

Table 1: Example of science-related teaching license renewal training at the University of Tsukuba in 2018

Also, if we look at the subjects, there are some variations and most classes offer a wide variety of interpretations. Given that the training is done every 10 years, it is possible for teachers to span three generations. Because of this, the school subjects and teaching experiences of fellow teachers offer an opportunity for the mutual exchange of opinions and viewpoints, which may spark new ways of thinking. On the other hand, from a lecturer perspective, lecturing in front of participants (teachers), depending on what subject is chosen, may give rise to generation gaps that in turn, lead to trouble. As such, those taking the class may not get the results they were expecting. This is probably not only true during the license renewal process but also when receiving training for a selected subject. It is thus important to consider the competencies needed for the teacher's current situation and life stage and make the training commensurate with those indicators. Also, the lecturer must consider the participants' conditions and needs when inspecting the detailed training content. Training that enhances both points of view holds the key.

Conclusion

The professional development of science teachers calls for a lifetime of continuous development above and beyond actual work. It goes without saying that attending one or two training sessions does not guarantee overnight success. At the same time, teacher training for science teachers is important if they wish to acquire more competencies and grow professionally. That will not and has not changed. As you have come to see in this article, Japan's teacher training is manifold and several opportunities are available for science teachers.

However, this teacher training is not without problems. For example, if we look at the results of the Organisation for Economic Co-operation and Development (OECD)'s 2013 Teaching and Learning International Survey (TALIS), while the motivation for training among Japanese teachers is high, the biggest barriers are trying to fit training sessions into busy work schedules (National Institute for Educational Policy Research, 2015, pp. 128–129). When this information is considered, both the opportunity for training and content enrichment and making an environment where it is easier for teachers to participate should be discussed as possible reforms.

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Teaching Standards and Competency Improvement Programmes: The Case of Okinawa Prefecture in Japan

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Abstract

What newest effo ts are ongoing in Japan amidst current educational reforms to implement 21st-century curricula to establish Society 5.0 beyond the Fourth Industrial Revolution? This article aims to discuss the newest Japanese in-service teacher training system and illustrate its use in the Okinawa Comprehensive Education Center. There are a number of articles that analyse the role of lesson study for professional development via lesson study projects. This article provides a bird's eye view of professional development by illustrating the Okinawa teaching standards that envision teachers' career paths and illustrate the teacher training programme that develops their competency in curriculum management. It also mentions how teacher training centres support every school to establish learning communities that produce and implement their own curricula through lesson study.

Keywords: Teacher standards, smart society, teacher professional development

Introduction

In the past 20 years, lesson study has been known as an international model for teacher professional development (Baba and Kojima, 2004 and Isoda, 2007 and 2014). At present, several effo ts to improve lesson study practice are ongoing worldwide (Huang and Shimizu, 2016). It is characterised as the "plan, do, and see" activities by a group of teachers and researchers. In their projects, difficultie and challenges were also reported as a result of researches. Among them is that adopting the lesson study approach does not always work like in Japan and every project should have their own lesson study project framework (Robutti, et al., 2016). What is missing is how teacher training is done and how lesson study functions as part of it. On this matter, some traditional limited information was provided in English to show that lesson study is part of the professional development system in Japan (Tanaka, et al., 2004 and Okubo, 2007). However, compared with the latest teacher education movements in the world, it was based on the old data.

What newest effo ts are ongoing in Japan to teach 21st-century skills and help teachers face the challenges of Society 5.0 beyond the Fourth Industrial Revolution? This article aims to provide information on the latest Japanese in-service teacher training system and illustrate it in line with the Okinawa Comprehensive Education Center's curricular reform.

In Japan, some public institutions are dedicated to improving educational quality. These include the National Institute for Educational Policy Research (NIER), National Institute for School Teachers and Staff Development (NITS), prefectural education centres in 47 prefectures or provinces, and city education centres in 20 mega cities. These institutions organise teacher training to achieve the national curricular standards and respond to local issues.

In Japan, 30% of the public schoolteachers' salaries is financed by the national budget under Ministry of Education, Culture, Sports, Science and Technology (MEXT) while the remaining 70% comes from the prefectural budget. Their hiring is conducted locally in each prefecture or mega city. As such, teacher training programmes use the budget of prefectures and mega cities. Teachers are transferred between schools within the local area where they were initially hired. Each teacher is assigned to the same school for five years or so. The training conducted at each centre is provided for trainers or supervisors employed within the local area.

Education and Teacher Training System

This article discusses the role of prefectural education centres using the case of the Comprehensive Education Center of Okinawa Prefecture as an example. It will illustrate the contents of teacher training specifically for curriculum management

First, the teacher training system in Japan must be explained. Public schoolteachers are obliged to undergo training, which is broadly divided between professional training, where costs such as travel expenses are paid for by schools, and others that do not provide such an allowance. Training without allowances are further subdivided between those with professional duty exemption, where principals allow staff to train during work hours, and voluntary training where staff pays for all costs and trains outside work hours. Professional training includes in-school training organised by individual schools, those organised by local school districts (i.e., city or county) or the prefecture, and national training. Some selected teachers by the districts are able to study at Universities upto Master Program in Education with their salaries. Voluntary training includes participating in lesson study groups, cooperating with university professors, and attending seminars and conferences. Professional training such as in-school training is organised either by the research department of each school under the supervision of its principal. School district or prefectural training is organised by training institutions or centres that the educational supervisors belong to. At times, external specialists such as university professors are invited as external lecturers. Teachers also have to renew their licenses every 10 years. They have to participate in license renewal seminars organised by universities or academic societies as voluntary training with allowances from MEXT. Most of the training organised by the centres are professional on-duty training.

Lesson study is broadly implemented both internally as part of teachers' jobs and training organised by study groups. Schools affili ed with universities hold an open class every year while national or prefectural research schools hold an open class once every few years. Every elementary and junior high school has visiting days for parents. In elementary schools, a visiting day is organised at least once or twice each year while open classes are regularly organised for parents or guardians. This custom, which allows people to observe classes, makes it easier for teachers to actively engage in lesson study.

Revisions to national curricular standards are conducted separately for each subject based on sampling surveys, results of lesson studies in schools affili ed with universities and designated research schools, and national themes for educational improvement. Each textbook is written by in-service teachers under the supervision of university professors, prepared by the publisher, and examined by MEXT if it satisfies the national curricular standards. Only certified textbooks are selected by each school district and distributed for free, subsidised by the national budget, to all elementary and junior high school students. The curriculum is organised by each school based on the national curriculum standards. Schools have to develop their own curricula. They are allowed some fl xibility—10% for elementary and junior high school and 20% for senior high school. Every year, a national achievement survey for mathematics and language is conducted among all elementary sixth graders to junior high third graders. The national sampling survey for curricular reform is conducted among all elementary sixth graders to junior high third graders. These surveys do not examine the achievement of individual students but assess how well the national curriculum standards were implemented. They also provide information to every board of education about each school's achievement and indirectly, its teachers. The information is only known by supervisors (i.e., MEXT and boards of education), as it is useful for both planning training and improving curricula.

Training organised to revise the national curriculum standards cascades through the following levels—national centres, prefectural centres, school districts, and schools. In terms of curricular reform issues, the study themes for lesson study are usually proposed. Examples include studies to propose innovative educational methods and teaching contents for reform, implement new curricula, and improve the qualifications and compe encies of individual teachers.

The fact that the mathematical competency of Japanese students is high (i.e., ranked top among the 37 members of OECD based on the ***PISA (2018) in Mathematics***) is due to the long-term comprehensive improvement of the pedagogical content knowledge of Japanese teachers through lesson studies conducted under training systems. The superiority of Japanese-style lesson study is acknowledged by other countries and recognised as a problem-solving approach to nurture students who learn and think by and for themselves.

On the other hand, it has been pointed out that a simple imitation of the approach does not always lead to improvement in student achievement (Robutti, et al., 2016). The foundation for such competency improvement depends on the quality of implementation, teachers' comprehensive levels of material study achieved through lesson studies, and the advanced extent of sharing such knowledge through revising textbooks. This foundation can be established progressively but cannot be achieved in a short span of time (Isoda, 2014). Deepening teaching material and lesson studies for sharing better teaching approaches is the permanent objective of every education centre and municipal supervisor.

Role of the Comprehensive Education Centre of the Okinawa Prefecture

The centre of each prefecture started as an education research institute after World War II. Later, their training function was strengthened and they became teacher training centres. Their general education improvement function was then strengthened so they could become comprehensive education centres.

Here, we focused on the case of Okinawa because it is a prefectural education centre. Its role differs from those of national centres, NIER, and NITS. The regional nature of Okinawa requires solutions to local issues. Before explaining the centre's functions, the regional characteristics of Okinawa must first be discussed

Japan is an island country with a total length of 3,000 kilometres. Okinawa is located in the south and consists of islands with beautiful coral reefs. It was an independent country before it became part of Japan in the 17th century. It continues to influence its own unique history and culture. For instance, karate was developed in Okinawa based on Chinese martial arts. It started to spread through Japan in the 1910s and became taekwondo in Korea after the 1940s. On the other hand, Okinawa had heavy battlefields during World War II and was under American control until 1972 before it was returned to Japan. Due to this history, it was underdeveloped. It also faced many challenges in the field of education. For example, for many years, it was at the bottom of national surveys (i.e., ranked 47th) for mathematics. However, its student achievement has improved in the last four years. Now, it ranks sixth in Japan. Under the board of education, the centre has been playing a central role in improving student achievement.

The functions of this centre comprise doing investigative research, hosting workshops for students and educational consultations for parents, providing information, and conducting training. The investigative research function includes embarking on studies to improve the ability of schools, enhance teachers' skills, and promote "zest for life" (i.e., the slogan of the national curriculum standards) among students. For instance, it conducted research to investigate and plan for training contents necessary to conduct classes to achieve school goals. For this, the supervisor or teacher trainer from the centre regularly visited schools to offer advice. In terms of workshops for students, it provided ICT-engineering and food processing training in vocational schools. These included programmes or presentation preparation workshops that promoted collaborative inquiry. For its educational consultation function, it supported students who were failing to fit into their schools, advised students on university and/or career choices, and supported handicapped children so they can attend school. Providing information included publishing research results and teaching materials, such as books; supporting educational and cultural activities; publishing digital content; and operating the prefectural network system. The training function includes legal training for newly employed teachers; training after 10 years of employment; additional training for two, three, and five years of employment; training for 15 years of employment; training for managerial positions; training for head teachers per grade; long-term training that required staying in the centre for six months; short-term training during the summer break; and specially delivered training conducted in schools upon request. In the summer, teachers are required either to work in school or train at the centre and other institutions. The centre organises 80 courses for short-term training during the summer. Breaks between semesters for students are not holidays for teachers but time for preparing, learning, and studying.

Teaching Standards: Career Path for Teachers

Since the consistent development of teachers is required after hiring, teaching standards have been established in countries worldwide (in Southeast Asia, examples include the Southeast Asia Regional Standards for Mathematics Teachers [SEARS-MT], 2014 and the Southeast Asia Teachers Competency Framework [SEA-TCF], 2018). The report of the Teacher Training Subcommittee of the Central Council for Education (MEXT, 2015), demanded the professional development of teachers and a clarification of their career path, which were documented by each prefecture. In the report, every prefecture set teaching standards. Okinawa set the Ideal Competencies for Teachers and the Career Developmental Stages of Teaching aided by the Okinawa School Board of Education (2017). The competencies and stages became part of indispensable goals for planning and implementing teacher training at the centre. The competencies are considered the principles that underlie requirements for teachers, namely:

- **Ethics, sense of mission, and responsibility:** As a public servant, teachers should act according to ethical standards, have a strong sense of mission and responsibility, and must be aware that the citizens of the prefecture trust them with the noble mission of looking after the development of their children.

- **Educational affection and awareness of human rights:** As a teacher who works with children daily and greatly influence their growth, one must be able to interact with children with true educational affection and high awa eness of human rights.

- **Rich humanity and ability to continue learning:** As an educator who will open up children's future, one must be able to continue learning as a highly specialised professional to mature and nurture humanity.

These teaching principles served as the foundation for the following career stages defined according to experience (see Table 2).

These are the career stages defined by Okinawa. Each stage has required competencies and development stages in accordance with the students' situations (i.e., understanding students and their skills for individual and group teaching), the school management (e.g., coordination and cooperation, safety and risk management, problem-solving ability, administrative skills, and information utilisation and management skills), and practical skills for implementation (i.e., curriculum planning, teaching practice and assessment, and lesson study and improvement). Every goal for the training programmes conducted by the centre is clarified in reference to some aspects of the principles and competencies.

Take initiative Hiring stage First year	You teach based on your students' current foundational knowledge and skills. You must be aware of your position as a teacher in Okinawa. That means you can perform your duties as a member of the school staff while actively seeking the advice and recommendations of other teachers.
Fulfill your responsibilitie Basic stage Around the third year	You teach based on your students' current foundational knowledge and skills. You fulfill your esponsibilities while cooperating and coordinating with your fellow teachers.
Lead educational activities Fulfillment stag Around the eighth year	You enrich your knowledge and skills by participating in and crafting your own educational activities. You can enhance your school's networking system and improve camaraderie among staff by actively engaging with peers, especially your less-experienced colleagues.
Play a central role Development stage Around the 13th year	You can promote your school in the community by showing off your xpertise and strengths. You can play a more central role in the school network and even join division competitions. You should also be able to instruct and advise fellow teachers.
Take on a comprehensive perspective Instructor stage After the 18th year	You can promote school activities effectively and efficiently by showcasing your knowledge, skills, an experience. You should be able to support your school network while nurturing fellow teachers to gain the same comprehensive perspective.

Table 2: Teaching Career Path: Five Stages of Professional Development

Case Study: Curriculum Management Training to Nurture Children Who Will Build Society 5.0 beyond the Fourth Industrial Revolution

The case study is based on the curriculum management training conducted by the author (i.e., Tomori), which was one of the 80 courses held at a summer training in 2018. Curriculum management is one of major issues identified with regard to reforming the national curriculum standards (MEXT, 2017) and teachers have to prepare its implementation from 2020 onwards in school. The training course was a three-day workshop in mathematics held for teachers in management positions, research chiefs, and ordinary teachers. It aimed to teach curriculum management to enhance the national curriculum standards so teachers can match their schools' unique contexts and plan the implementation on their own lessons for mathematics.

The national curriculum standards (2017) defines curriculum management as follows

> *"Every school organisationally and systematically ensures the improvement of the quality of their educational activities based on its own curriculum through knowing the current status of students, the school, and its surrounding area; preparing the necessary educational goals and teaching content with cross-cutting perspectives across curriculum subjects; improving the implementation process of its own curriculum by assessing its current status; and systematically securing the human and material resources necessary for implementing the curriculum. These are summarised by three aspects—a horizontal perspective across curriculum subjects, the plan-do-check-act (PDCA) cycle, and the utilisation of educational resources."*
>
> *—Revised by Tomori, https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo3/siryo/attach/1364319.htm*

The first questions as ed during the workshop were:

- How is our society changing?
- What are the competencies required in this changing society?
- How will you set the educational goals or aims of your school for this current situation?

The participants or trainees held free discussions and group work during the seminar that introduced Society 5.0, which is an alternative society under the Fourth Industrial Revolution that involved AI and robots. The report for Society 5.0 was published by the Cabinet Offic (2016) and the Ministry of International Trade and Industry in 2017. It was adapted by the National Education Council in 2018.

The main themes of the 2016 curricular reform was nurturing competencies for humanity towards learning (i.e., engaging in the society and world for a better life or soft skills), utilising what one understands and is capable of (i.e., competency for thinking, judging, and expressing or cognitive skills), and identifying what one can understand and is capable of (i.e., knowledge and skills or hard skills). These three points are concretised by the curriculum standards for every subject. MEXT wants to develop a general competency that can be used for the establishment of Society 5.0, particularly one that relates to problem posing and solving, which includes critical thinking and deep learning. Teachers usually relate subject teaching to specific knowledge and skills so they need to study two other points. This should be done across all subjects to make them comprehensive and well-balanced, allowing students to gain a zest for life.

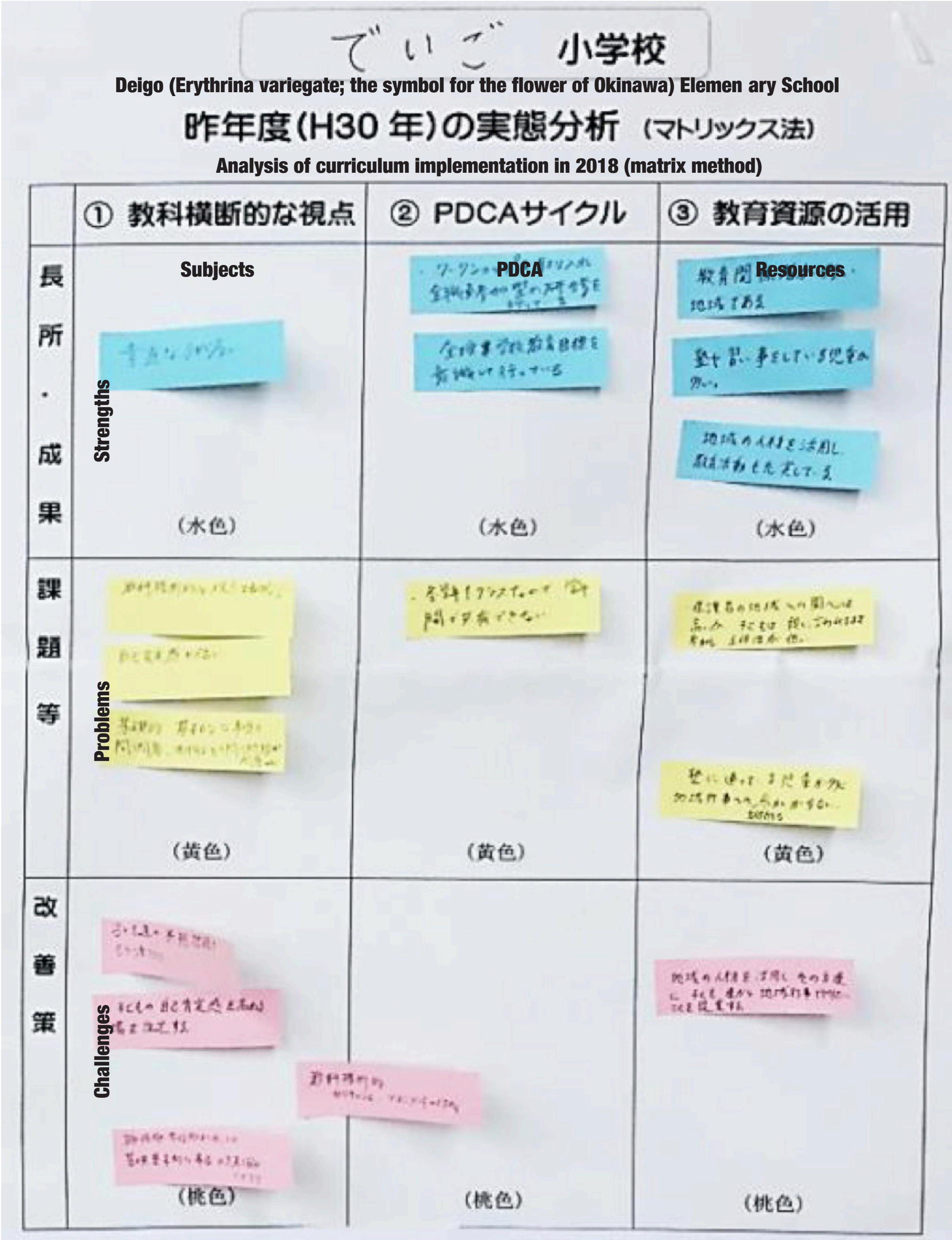

Figure 12: Matrix showing the current status of implementation in school

In reference to the above-mentioned goals and discussions, the sense to recognise challenges matured. Part 1 of the workshop started with group discussions of local issues and asking the groups to give a school name based on their ideas of societal innovation. Then they are asked to analyse the current status of the school in relation to their experiences in the past year. They then enumerate strengths, problems, and challenges with regard to every aspect of curriculum management. Finally, they organise their findings using a matrix (see Figu e 12).

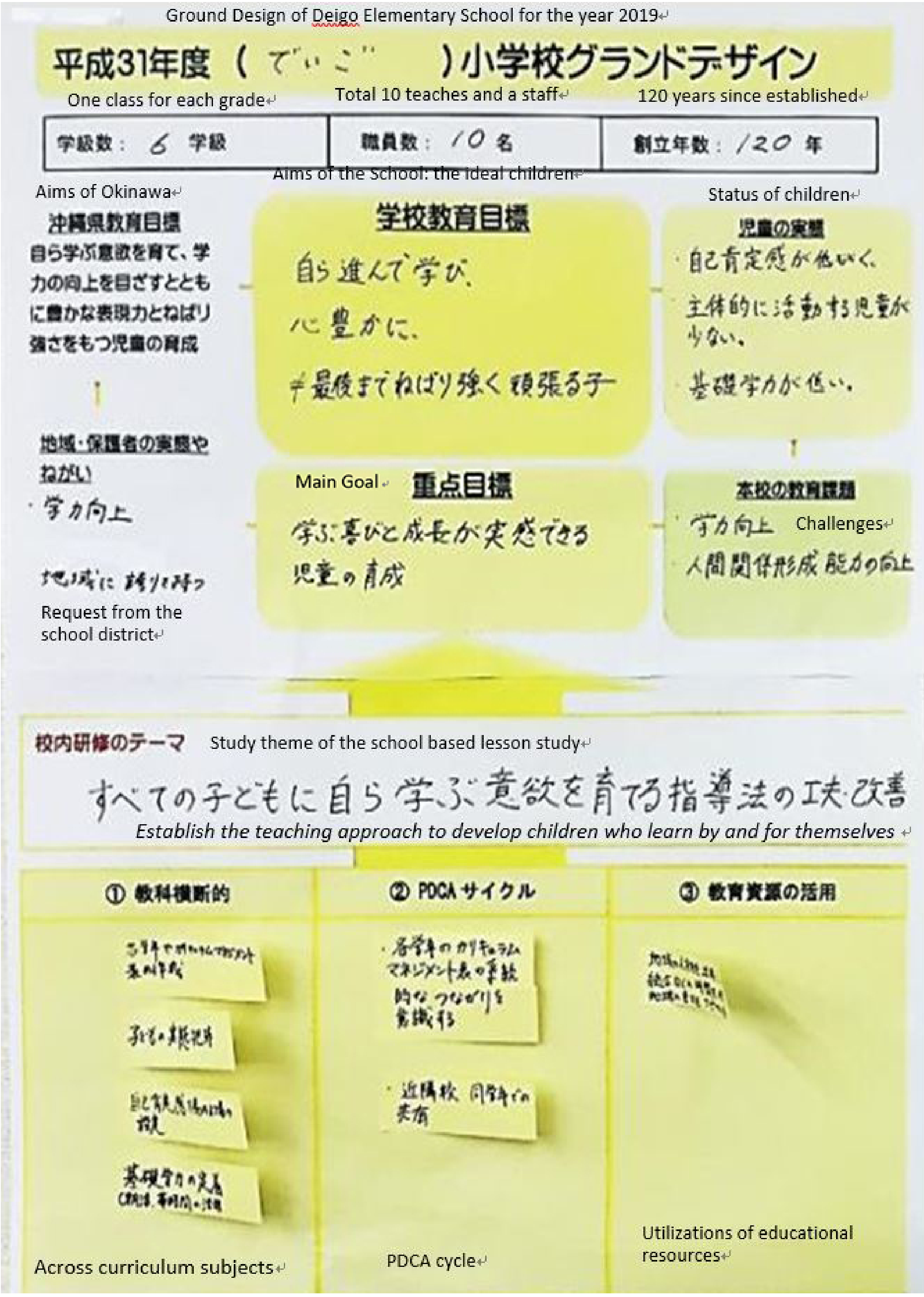

Figure 13: Set the school's goal along with tasks for curriculum management

Part 2 involves a discussion of the grand design for curriculum management for the next academic year within each group. This grand design should take the form of a table (see Figure 13). The table's components include the school goals, their image of ideal students, and the themes of school-based lesson studies. In Japan, these are usually planned by small groups that include the principal and the research chief and committee members, then approved during a staff meeting. In reality, teachers are usually too busy and their schools cannot easily provide them with opportunities and time for such planning as a whole school. It is, however, possible if made part of a summer training course because they get the time to spend on such an activity, which is necessary for their career development. They learn how to design curricula on their own.

Part 3 involves planning for a class based on the grand design. Each group prepares a lesson study proposal with a lesson plan and discusses how the contents of the lesson plan corresponds with the grand design. Figure 14 shows the lesson plan format, which includes how to utilise the chalkboard in class prepared by the trainer as an exemplar on addition and subtraction for grade 2 mathematics. The lesson plan comprises the objective of the class (i.e., top section); students' ideas (i.e., middle section); the necessary activities from introduction to development to summary (i.e., left section); and points for assessment, homework, and reflection (i.e., right section)

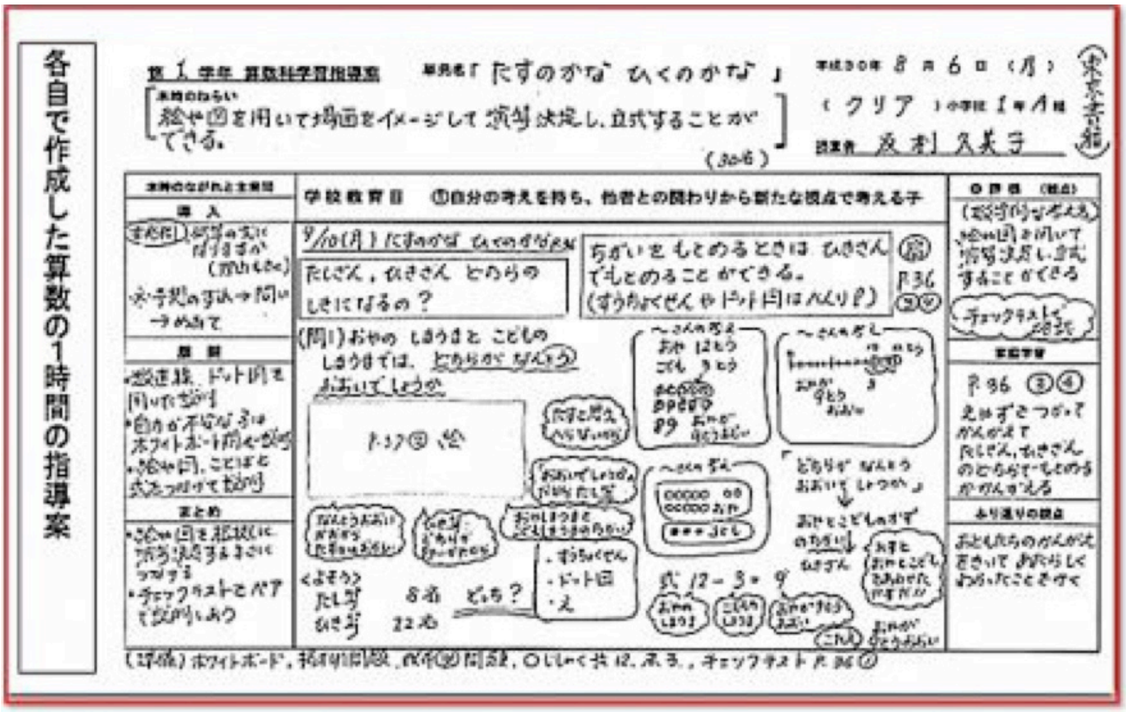

Figure 14: Lesson plan utilising a chalkboard to implement the grand design

A survey conducted after the training showed all positive responses, including how fun and important curriculum management is, how enjoyable the grand design activity is, and how the trainees gained a new perspective for conducting daily classes not only for teaching mathematics but also to nurture the competencies demanded by the curriculum. The curriculum management training is part of summer training programmes, which teachers at diffe ent career stages attend. Heterogeneous groups also worked when it came to sharing experiences. The training also exceeded the session capacity because the topic was new.

Conclusion

This article illustrated how the centre conducts teacher training using the curriculum management training as an example. As shown, the training activities are very Japanese in that they were very detail-oriented and aligned with professional skill acquisition goals, as described by the competency model for teachers. Training was planned well and showcased schools as learning communities for teachers who learn together to establish professional learning community. The lesson plan preparation for lesson study also helped schools realise their goals while satisfying the requirements of the national curriculum standards. The centre comprehensively promotes quality teaching to nurture children who can study and think for themselves to build the society for the next generation. After the training, the participants often requested support from the supervisors. This presents many opportunities for the centre to promote in-school lesson study through dispatch trainers and supervisors from the centre. While there are various types of training for teaching quality improvement in Japan, they all function in mutual coordination.

Globally, there are a number of lesson study projects that produce their own findings using social scientific methodologies. However, they usually analyse only focal parts of each lesson study. This article provided a bird's eye view of a case that showcased the comprehensive professional development model that a teacher's career path can follow. In the curriculum management training, every teacher trainee group produced a lesson study theme and plan according to how they envision the implementation of the school curriculum. The teachers learned to produce a lesson study to enhance the school as a learning community. This article illustrated how the teacher training centre supports every school to establish a learning community that contributes to planning and implementing the school curriculum.

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Inspecting Proactive Methods to Improve the Competencies and Capabilities of Japan's Science Teachers through Teacher Training: A Practical Example of the Foundation of Themed Research on Science Teacher Training

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Abstract

We inspected a practical example as the foundation of themed research on science teacher training so teachers can embody the image of a constantly learning professional through proactive methods to form and improve their competencies and capabilities. Through a specific example of a uniquely themed research with three characteristics, we believe teachers can proactively form and improve their competencies and capabilities. First, teachers should choose their own themes and forms of voluntary training in and outside school. Second, teachers can learn through various ways, such as observing video recordings of their classes and trial and demonstration lessons. Finally, teachers can work with trainers to pick theme for their research.

Keywords: Science teacher, teacher training, themed research

Introduction

With our country's teaching policies, the most important issue is to form and improve the competencies and capabilities of teachers so they can continue their inquiry and education (Central Council for Education, 2015).

The abilities that teachers need are universal and should correspond to the current era's changes. The former includes a sense of mission and responsibility towards teaching, love for education, professional knowledge related to subjects and teaching, and practical teaching skills and attributes that make teachers well-rounded people (Central Council for Education, 2012). The latter includes the strength to become a teacher in a drastically changing society.

The Central Council for Education's report, "How to Improve the Abilities of Teachers for Future School Education," which was published in 2015, highlights the various capabilities a teacher needs in the coming era. Among the capabilities dubbed necessary and especially important in a changing era are "the desire to continue learning and the ability and knowledge to gather, sort, and use information organically."

Many forms of teacher training are available to Japan's teachers so they can constantly learn and continue to improve their abilities. However, it is important to create an environment, where teachers are motivated to continue training despite their busy schedules. To solve these problems, MEXT used proactive reforms to promote a systemised teacher training programme at the prefectural and local levels (Central Council for Education, 2015).

How much can teachers raise their awareness about the need to continue learning and proactively improve their capabilities while trying to avail of teacher training opportunities? This article, which used a specific example of science teacher training, considered the path teachers can follow to constantly learn and proactively improve their capabilities through training.

Capabilities That Science Teachers Need

We mentioned the capabilities that teachers need earlier but what capabilities do science teachers need? Ohtaka (2008) discussed the difficult of categorising teacher competencies before breaking down the competencies that science teachers need into five ca egories:

1. **Pedagogical principle competency:** Ideas about education that support and form the basis of teaching competencies, including a sense of mission, passion, and the like.

2. **Basic practice competency:** A self-reliant teacher has the basic competency to make educational practice possible. This competency focuses on teacher training for beginners.

3. **Skillful practice competency:** This competency is gained by accomplished teachers through experience, accumulated training, and maintaining a high level of practical competency.

4. **Pedagogical research competency:** This refers to the competency to connect educational practices to research.

5. **Pure science research competency:** This is a specialised research competency to know what contents to present to particular classes.

These five competencies, taken on their own, do not add up to using effective educational tools. According to Ohtaka (2018a), pedagogical research competency alone does not lead to practical education practices. Basic practice competency alone limits the ability of teachers to handle the many problems we face today. Having skillful practice competency will not make immediate educational effects apparent because empiricism makes it difficul to form a basis for educational improvement. Pedagogical research competency or gaining theoretical knowledge of science education alone cannot allow teachers to keep up with the multitude of educational practices today. And finall , pure science research competency or specialist research competency alone will not guarantee full-fledged educational p actice.

As mentioned in the Central Council for Education's report (2012 and 2015), these five competencies together comprise the universal qualities a teacher needs. However, core competencies concerning foundational issues and elements of mastery require new abilities because of societal changes. Also, new abilities are required for educational and pure science research to progress. As such, science teachers need to have all of these new competencies. They need to balance these five core competencies while improving their already existing competencies and capabilities.

A Specific Teacher Training Example to Improve Science Teachers' Capabilities

Japan has various kinds of teacher training offe ed by prefectural educational centres. To improve teaching skills for a new age, new sorts of training content and forms, such as improving classes in terms of active learning, are necessary. A review of the current structure of science teacher training should not only be about finding new contents and forms but also about making existing training more proactive. Themed research where teachers decide on the themes themselves is required.

A science teacher's themed research is one that cultivates a subjective and practical attitude towards a topic of interest. Of the five competencies, teachers would benefit most by acquiring skillful practice, pedagogical research, and pure science research competencies.

Themed research projects need at least a year to complete. So how does it fit into various teacher training programmes? How can it be practiced?

The type of teacher training and life stage of the trainees must be reflec ed in the training. That said, let us look at where themed research fits with detailed xamples.

Types of Science Teacher Training

The ***Teacher Training Guide 2018*** published by NISTSD lists the types of teacher training in Japan (see Figure 15). These types were compiled from places where training sessions are held and fall under three big categories—self-training, in-school training, and out-of-school training.

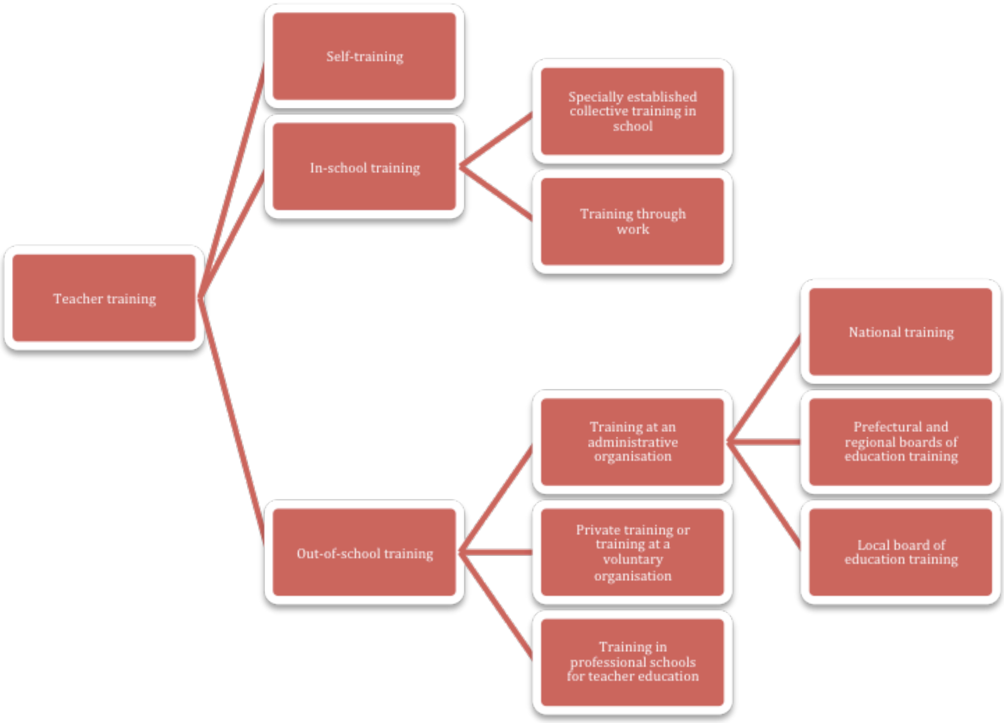

Figure 15: Types of teacher training in Japan (NISTSD, 2018, p. 3)

In self-training, teachers undergo individual training on their own. In-school training, meanwhile, occurs within the school where the teachers work. It is further subdivided into collective and OJT. Finally, out-of-school training occurs somewhere other than the teachers' employers. It is further subdivided into three categories—training through an educational administration organisation, private sector training or training at a volunteer organisation, and training at a professional school for teacher education.

Note, though, that training in an educational administration organisation can occur in and outside the teachers' schools. For example, beginner training for newly hired teachers requires at least 25 hours of out-of-school training and 300 hours of in-school training per year (MEXT, 2019). Themed research for science teachers differs by prefecture but is often incorporated into training required during the year.

Science Training by Life Stage

Training is also sorted according to the life stages of teachers. Let us take a concrete example. Teacher Y who has spent 13 years teaching at X Prefectural High School received long-term teacher training suitable to her life stage. Y went to the X prefecture educational centre for beginner training in 2001 and took science teacher training courses 10 times. The training mainly consisted of themed research. Furthermore, Y used her teaching experience to participate in several short science training sessions outside the typical teacher training.

Years of Experience	Training Outside School	Science Teacher Training
First year	Beginner training (legal training) 28 times + volunteer activity training	Themed research 10 times
Fifth year	Fifth-year teacher training (based on teaching experience) 5 times + societal experience training	Youth Science Museum in T City societal experience training 1 time (5 days)
Seventh year	Special teacher training at a prefectural centre 25 times	Themed research 16 times
10th year	10th-year teacher training (legal training) 10 times	Themed research 6 times

Table 3: Y's long-term teacher training through the National Prefectural Board of Education (2001–2013) based on her records from X Prefectural Educational Centre in 2001, 2005, 2007, and 2011

As shown in Table 3, beginner and 10th-year training are required for all teachers. In X prefecture in 2005, high school teachers also had a fifth-year training. X prefecture held a special teacher training at the prefectural education training centre to nurture teachers who can take on leadership roles in local schools and other areas and raise the quality of teaching materials and leaders. This training targeted teachers with five or mo e years of experience.

In this example, where the teacher completed 16 science training themed research as part of the 25 out-of-school training sessions, Y with 13 years of experience exerted the most effo t on themed research. The contents and an analysis of the special themed research Y conducted is included in this article. The case study was based on Y's teacher training records and materials as of 2007.

Sample Themed Research in Science Teacher Training

Y spent 2007 (April 2007–March 2008) in special teacher training at X Prefectural Education Centre. Science teacher training was included in the overall training. The contents of the 16 science teacher training sessions are shown in Table 4, which together made up the themed research. A high school science teaching consultant led the themed research. Y, who is a high school biology teacher, joined the training along with two other teachers—B who is a high school biology teacher and C who is a high school chemistry teacher. The theme of the science teacher training was "Tools to Enhance the Integration of Instruction and Evaluation in Integrated Science B: Introducing the One-Page Portfolio (OPP) Assessment."

Session	Time	Contents of Science Teacher Training
1	Mid-April	Understanding and working towards solving issues to improve lessons
2	Late May	Analysing policies in detail to improve lessons by observing class videos and through lesson study
3	Mid-June	Report on progress made to improve lessons and detailed analyses of policies
4	Late June	Report on progress to improve lessons and detailed analyses of policies
5	Early July	Decide on a research theme and analyse and report on progress to improve lessons
6	Mid-July	Identify improvements based on the training and announce and confirm themed esearch plans
7	Early August	Report themed research progress and self-training during the summer vacation and embark on literature survey for the themed research
8	Late August	Trial classes and lesson study
9	Early September	Report on and analyse progress on themed research
10	Mid-October	Create and submit midterm report for the training
11	Late October	Observe class of an accomplished biology teacher (D)
12	Early November	Observe demonstration lesson and lesson study of a chemistry teacher (C)
13	Mid-November	Perform demonstration lesson and lesson study
14	Late November	Report on and analyse progress of themed research
15	Mid-December	Observe demonstration lesson and lesson study of a biology teacher (B)
16	January	Finish themed research and create and submit the final eport

Table 4: Special teacher training on themed research received by Y at X Prefectural Education Centre in 2007 (Source: Record of Y's teacher training in 2007–2008)

We will explain the contents of the various training sessions listed in Table 4 in more detail below.

The first session is about understanding and working to solve issues surrounding lesson improvement. In detail, each trainee thought about issues he/she faces during lessons then lists ways to solve these. The trainees then collaborate with others and focused on issues with the help of the teaching consultant.

In the second session, detailed policies to improve lessons were analysed and lessons by each trainee were recorded and observed. Lesson study was also conducted. In Y's case, upon the advice of the teaching consultant, she improved her class by using a OPP for Integrated Science B based on the school's and students' needs. The OPP was developed in 2002 by Hori. In it, the teacher recorded his/her aims and listed his/her scholastic records before, during, and after the study (Hori, 2004).

On the second day, the teachers recorded their regular classes in their respective schools. They were also observed as part of the training. The observations served as the basis of their lesson study. A lesson study aims to develop a teacher's professional competencies. To do so, it requires targeting and analysing an actual class as part of the research meant to develop the teacher's professional competencies (NASEM, 2009). Japan's lesson study is attracting international attention and being highly evaluated. It is likely to spread around the globe.

The third session involves a progress report on lesson improvements and an analysis of the detailed policies for later use. Y created an OPP, received feedback from the teaching consultant and other trainees, and made improvements.

The fourth session also required a progress report on lesson improvements and an analysis of the detailed policies for later use.

The fifth session was based on lesson improvements made so far. Each trainee established his/her research theme on lesson improvements. Y's theme was "Making a Lesson That Builds Student Interest and Engagement Using an OPP."

The sixth session reviewed the science teacher training in the past four months and confirmed the direction of each person's self-training. Y listed the benefits enumerated by students in the OPP, which she showed to the teaching consultant and other trainees for feedback.

In the seventh session, a report on the progress of the themed research and plans for self-training over summer vacation were submitted. A literature survey for the themed research was also conducted. Y reported on a diffe ent training (i.e., an environmental training conducted by X Prefectural Education Centre) that she participated in during summer and did an OPP literature survey for.

In the eighth session, the trainees conducted trial lessons and lesson studies on their themed research. Y used the OPP approach and conducted a trial lesson on biological evolution for Integrated Science B. She distributed a lesson guide to the other trainees, which they used as analytical materials in the lesson study held after the class.

In the ninth session, a report and analysis of progress of the themed research were conducted. In September, the second semester started and the trainees confirmed their detailed plans for lesson improvement. Y received advice from the teaching consultant on using the OPP to bring about detailed improvements.

In the 10th session, an interim or midterm training progress report about the training was created and submitted. Each trainee reconfirmed his/her reasons for the themed research and the steps and analysis methods employed to achieve lesson improvements.

In the 11th session, they went to S Public High School in X prefecture and observed a biology class conducted by an accomplished teacher we will call "D" (i.e., dissecting a chicken). After the class, the trainees wrote down their observations, which they can use to improve their own classes and submitted them to D.

In the 12th session, they went to T Public High School in X prefecture to observe C's trial lesson and lesson study.

In the 13th session, Y used the OPP approach for a trial class and a lesson study at her school. Y created a teaching guide that served as educational materials for her demonstration lessons and lesson study. In these, the teaching consultant, other trainees, and other science teachers from Y's school offe ed advice on how she can improve the lesson.

In the 14th session, a report and analysis of the progress on the themed research were conducted. In Y's case, the content of her new OPP was analysed.

In the 15th session, they went to M Public High School in X prefecture to observe B's demonstration lesson and conduct a lesson study.

In the 16th session, each trainee concluded his/her themed research. In detail, the trainees summarised the reasons for their themed research, plans for improving lessons, daily detailed practices, and achievements in demonstration lessons and lesson studies, which they discussed with the teaching consultant and fellow trainees.

That concludes the introduction of the teacher training content at this time. Three points about the overall training and characteristics of the themed research are mentioned here.

First, the training took on a combined form with the themed research selected by each trainee, with training at the comprehensive educational centre, the actual practice of themed research in school, literature surveys that were conducted within and outside school, and self-training.

Second, each trainee was observed in diffe ent ways through class recordings, trial classes, and demonstration lessons. These all resulted in time spent on lesson study.

Third, the trainees collaborated on ways to improve their lessons and exchanged opinions. Though their research themes diffe ed, they worked together on lesson improvements. The teaching consultant advised them on lesson improvement strategies when appropriate.

Y was able to spend a year on the subject of science teacher training within her unique themed research. After this teacher training, Y taught using her OPP to improve lessons continuously until she retired six years later. This is a unique example and analysis of a science teacher but also shows how teacher training allows a person to improve his/her capabilities and competencies in a core subject.

Conclusion

In this article, we introduced and analysed how teachers can continue to learn and aim to improve their core competencies and capabilities in their subject matters through teacher training by focusing on examples of science teacher training themed research. It is difficul to make the time and motivate teachers to attend teacher training. However, if effo ts are exerted to improve lessons and deal with issues, teachers will improve their main competencies and capabilities. Like Y, teachers can match their research themes to their own practices to raise their awareness of the importance of continued training.

This sort of themed research is conducted over a long time. One line of thinking is that the pressure of doing lessons at one's school puts a big burden on the trainee. However, with regard to revisions in curriculum guidelines, great emphasis has been placed on the process of inquiry and research activities in science (MEXT, 2017). It can be said that they form the core of the new curriculum guidelines (Ohtaka, 2018b). And if we are to expect young students to conduct their inquiry independently, they must elevate the abilities of the science teachers tasked with their education. For teachers to maintain a constant spirit of curiosity to promote their own learning, the most effective policy is for them to actively take advantage of research opportunities that explore science teacher training, which will help them proactively identify issues and make improvements in the practical aspects of education.

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A New Framework for Statistical Thinking in the Time of Big Data and the Digital Economy

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Abstract

This article introduces a five-phase framework for the statistical thinking needed for processing big data and using AI-driven data analytics platforms. The five phases identified by the framework are patterns and relationships from data, questions, objectives, data mining, and designing. The framework describes how statistical thinking processes have evolved from a traditional question-then-answer analysis to a more creative approach, which starts with data-based answers from examining opportunistic data and then works backwards to find the questions that should have been asked. In order to help illustrate how the proposed framework can be implemented at the school level, an exemplar application related to aging population issues is provided and a step-by-step description of the statistical thinking processes involved is presented.

Keywords: Statistical thinking, STEAM Education, big data, digital economy, curriculum framework

Introduction

The interest in big data is growing exponentially in today's society. Commercial insights, government initiatives, and even research calls all seem to focus on exploiting the potential of technology to capture and analyse massive amounts of data in increasingly powerful ways. Big data, namely, data that is too big for standard database software to process, is everywhere. For some, big data represents a paradigm shift in the way we understand and study our world and, at the very least, it is seen as a way to better utilise and creatively analyse information for public and private benefit

The concept of big data "refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyse" (Manyika, et al., 2011, p. 1). Additionally, big data is often associated with key characteristics that go beyond the question of size, namely, volume, velocity, variety, veracity, and value (5Vs) (Storey and Song, 2017). Big data is dispersed among various platforms that operate with diffe ent standards, providers, and degrees of access (Ferguson, 2012). For example, a lot of work in big data focuses on ***Twitter***, the blogosphere, and search engine queries. All of these activities are not undertaken equally by the whole population, which raises concerning issues surrounding the question, "of whose data traces will be analysed when using big data".

There are also a number of practical issues related to working with big data. These include, among others, issues we cannot affo d to ignore, such as implications for the training of future teachers regarding handling and analysing large datasets, including big data (Isoda, Chitmun, and González, 2018).

Due to the fact that big data has recently become mainstream in many research fields, including education, and the ability to handle big data is considered a key to success in a world driven by the digital economy, it is important to discuss and answer the following questions:

- In order to function effectively in a society driven by big data and the digital economy, what are the necessary processes of statistical thinking required to handle big data?
- How can we revise current curriculum frameworks for statistical thinking to incorporate big data for the digital economy?
- How can we incorporate core ideas of big data for the digital economy into the high school curriculum?
- What are plausible instructional activities (i.e., exemplar applications) for teaching the fundamental ideas of statistics while fostering statistical thinking for big data and the digital economy?

A New Framework for Statistical Thinking

Many researchers (e.g., delMas, 2002; Isoda, et al., 2018; Wild and Pfannkuch, 1999; Watson, 2017; and Wild, Utts, and Horton, 2018) consider statistical thinking as the practice of statistics through the enactment of the diffe ent thought processes involved in statistical problem solving and investigation. In this digital era, statistical thinking processes do not follow the problem-plan-data-analysis-conclusion (PPDAC) cycle (Wild and Pfannkuch, 1999) anymore due to the shift in the way we work with data, set by the arrival of big data analytics. In fact, the PPDAC cycle is a question-then-answer research method that focuses on data gathered for a purpose using planned processes, chosen on statistical grounds to justify certain types of inferences and conclusions. However, in terms of big data, this is actually a weakness because most of the big data available is opportunistic (i.e., happenstance or "found") data, this is huge amounts of data already collected by others and hosted somewhere (Wild, et al., 2018). Nowadays, many companies have data teams exploring large sets of raw opportunistic data, looking for new connections and identifying significant correlations while refining their analyses until they arrive at valuable meanings. This approach reverses the question-then-answer process of the PPDAC cycle. It starts with strong, data-based answers and then works backwards to find the questions that should have been as ed.

We must acknowledge that any up-to-date framework for statistical thinking must be designed, giving consideration to these criticisms to the PPDAC cycle. By doing so, we came up with the following framework to describe how a person engages in statistical thinking when handling big data. The proposed framework understands statistical thinking as a cognitive process comprising the following five phases

Questions

Pose critical and worrying questions in order to find plausible explanations to the patterns and relationships found.

Objectives

Set objectives related to the questions posed, in order to analyse the data.

Data Mining

Reexamine the data in light of the objectives, explore old and new data sources, or introduce new variables for consideration. Data mining can be data-, explanation-, or future-oriented.

Designing

Based on the results of the data mining, statistical thinkers develop an understanding of the past and present conditions of certain topics of interest. This understanding enables them to generate ideas for new activities and design plans and strategies for the future, aiming to turning such ideas and plans into something valuable.

Exemplar Application of the Framework: Aging Population Issues in APEC Member Countries

For the purpose of exemplifying this framework, let us suppose that we are interested in exploring issues related to population aging, which is a concerning issue in many societies, such as Japan. We can thus check the worldwide trend of web searches for terms such as "social security" and "nursing home," focusing on Asia-Pacific Economic Coope ation (APEC) member countries.

For this example, we will use ***Google Trends*** (https://trends.google.com), which is a publicly accessible online platform for big data that enables creative discovery from information on how frequently a given search term was entered into Google in real-time or within given time and date constraints.

Patterns and Relationships from Data

Using ***Google Trends***, we looked for patterns and relationships within the data hosted on the platform, based on our interest in aging population issues in APEC member countries. Then, by checking the worldwide trend of web searches for terms related to aging population, such as "social security" and "nursing home," we will be able to identify possible patterns and relationships in the data regarding the issue. Figure 16 shows the worldwide search trends for "social security" and "nursing home" from 2004 to 2018.

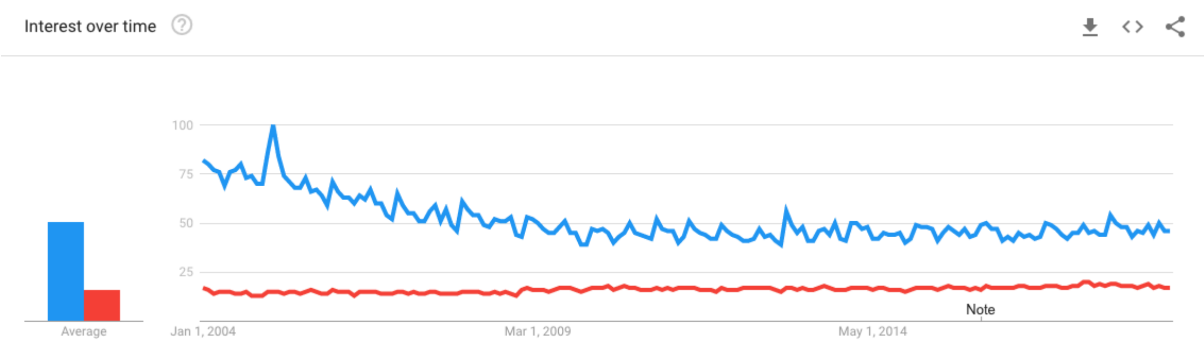

Figure 16: Worldwide search trends for "social security" (in blue) and "nursing home" (in red) within 15 years (i.e., 2004–2018)

Now, let us focus on the online search trends for the terms "social security" and "nursing home" in APEC member countries. In the top row of Figure 17, we can see that in 2018, more searches for "nursing home" were seen in Japan, Canada, and the U.S. than for "social security." On the other hand, in the bottom row, we can see that more searches for "social security" were seen in Chile, Peru, and South Korea than for "nursing home."

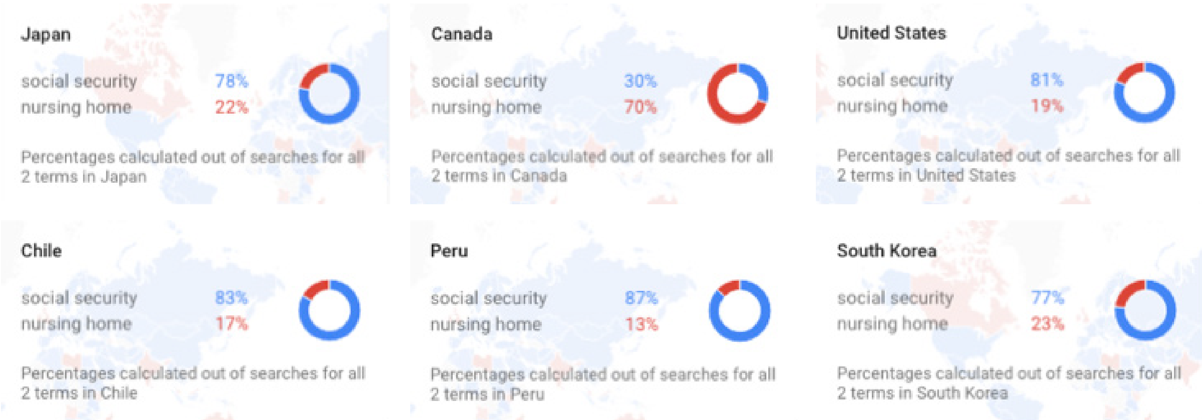

Figure 17: Comparison of searches for the terms "social security" (in blue) and "nursing home" (in red) in six APEC member countries in 2018

Questions

From the visual representations obtained using ***Google Trends***, it is possible to pose a series of questions regarding the statistical information displayed, in order to find explanations to the patterns and relationships found. These questions can support the process of critical evaluation of statistical messages and lead to the creation of more data representations, informed interpretations, and judgements. Some questions that might be posed for this example are:

- Why do some countries, such as Japan, Canada, and the U.S., seem to show considerably more online search interest in "nursing home" than "social security"?
- Why do some countries, such as Chile, Peru, and South Korea, seem to show considerably more online search interest in "social security" than "nursing home"?
- What are the reasons for the decreasing and increasing trends shown by the graphs?
- What could these trends mean for individual APEC member countries, such as those shown in Figure 17, in the next decade?
- In countries, such as Japan, Canada, and the U.S., where there seems to be more online search interest in "nursing home" than "social security," what will the trend be like for related queries, such as "nurse"?
- In countries, such as Chile, Peru, and South Korea, where there seems to be more online search interest in "social security" than "nursing home," what will the trend be like or the reasons behind related queries, such as "tax" or "pension"?

- What is the social security policy like in countries that show considerably more online search interest in “nursing home” than “social security” (e.g., Japan, Canada, and the U.S.)?

- What is the current state of nursing home services provided to the elderly in countries showing considerably more online search interest in “social security” than “nursing home” (e.g., Chile, Peru, and South Korea)?

Objectives

Now, from the questions posed, we are able to set clear objectives to address. In fact, each objective should be associated with at least one question. In this example, some objectives stemming from the questions above are:

- To look for and identify the reasons why some APEC member countries seem to show considerably more or less online search interest in “nursing home” than “social security”

- To determine the behaviour of individual APEC member countries regarding individual queries, such as those mentioned above

- To predict trends in web searches for the terms “nursing home” and “social security” in APEC member countries in the next decade

- To determine the reasons behind the nature of related queries (e.g., “nurse” for countries showing more online search interest in “nursing home” and “tax” or “pension” for countries showing more interest in “social security”) in APEC member countries with regard to a particular search trend

Data Mining

During this phase of the statistical thinking process, addressing the objectives set in the previous phase will lead to a reexamination of the data, from which new insights and knowledge discovery will emerge from three types of data mining—big data-, explanation-, and future-oriented.

For the purpose of exemplifying this phase, let us address objective 1 (i.e., look for and identify the reasons why some APEC member countries seem to show considerably more or less online search interest in “nursing home” than “social security”). In the case of Japan and other APEC member countries, the main reason can be the current structure of the population pyramid (i.e., explanation-oriented data mining). In order to construct plausible explanations from the population pyramids, we need to select and transform the necessary data into the required form (i.e., big data-oriented data mining), as shown in Figure 18.

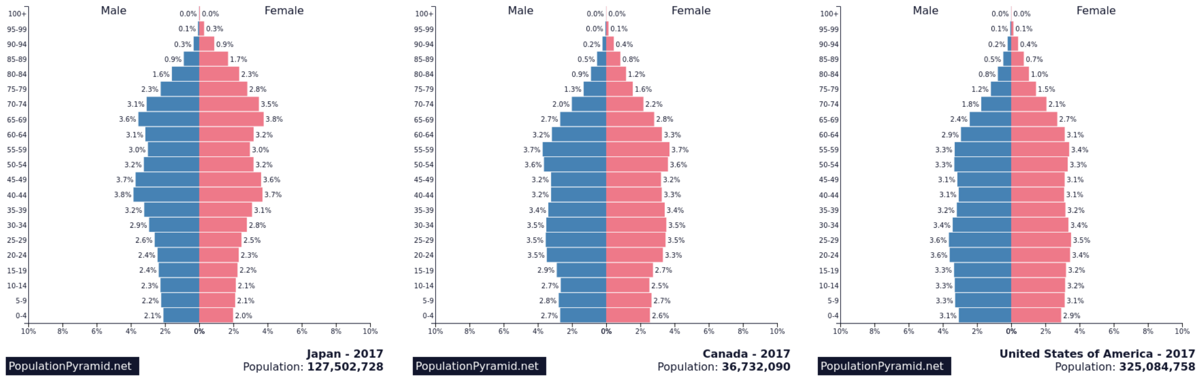

Figure 18: 2017 population pyramids for Japan, Canada, and the U.S.

So, if we look at the population pyramids of the APEC member countries in the top row of Figure 17, we can see diffe ent structures among the countries, regardless of the fact that in 2018, online searches for the term "nursing home" were higher in Japan, Canada, and the U.S. in comparison to the term "social security" (see Figure 18).

In Japan and Canada, we can observe a large proportion of the population close to or over retirement age. In the U.S., this phenomenon is not an issue, because a large proportion of the population is below 50 years old or far from retirement age. Thus, plausible explanations as to why some APEC member countries seem to show considerably more or less online search interest in "nursing home" than "social security" may vary from country to country. In the cases of Japan and Canada, a large group of elderly people close to retirement or who are already retired may be planning to live in a nursing home. In the case of the U.S., young people starting to make a life for themselves may be looking for information on nursing homes for their elderly parents.

From these hypotheses, we can make inferences and imagine the future of "nursing homes" in Japan, Canada, and the U.S. (i.e., future-oriented data mining) using big data to support our plausible explanations (see Figure 19).

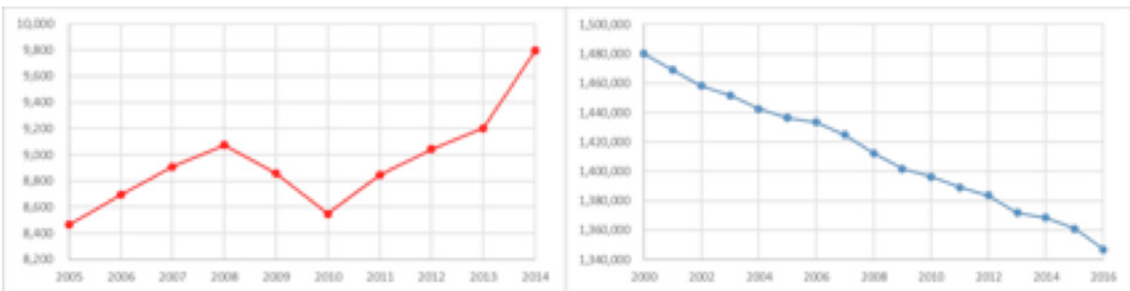

Figure 19: Number of nursing homes in Japan (red line, 2005–2014) and the U.S. (blue line, 2000–2016)

Designing

From the discovered knowledge, inferences, and plausible explanations generated in the previous phase, we gained valuable insights for the topics of interest (i.e., "nursing home" and "social security"). This understanding provides us with ideas to develop new activities related to the topics or variables of interest. Understanding the past and present allow us to design for the future, all supported by the data mining results.

In our exemplar application, from understanding the rising need for nursing homes and nurses in Japan, someone could design business plans targeting senior citizens to provide in-home care services, senior citizen transportation services, e-commerce stores for the elderly, wheelchair manufacturing plants, foreign nurse recruitment agencies, and so on. In the U.S., most of these ideas (e.g., a foreign nurse recruitment agency to provide care services for the elderly) will not work everywhere, but could be successful in some states, such as Oregon and Virginia, as shown in Figure 20.

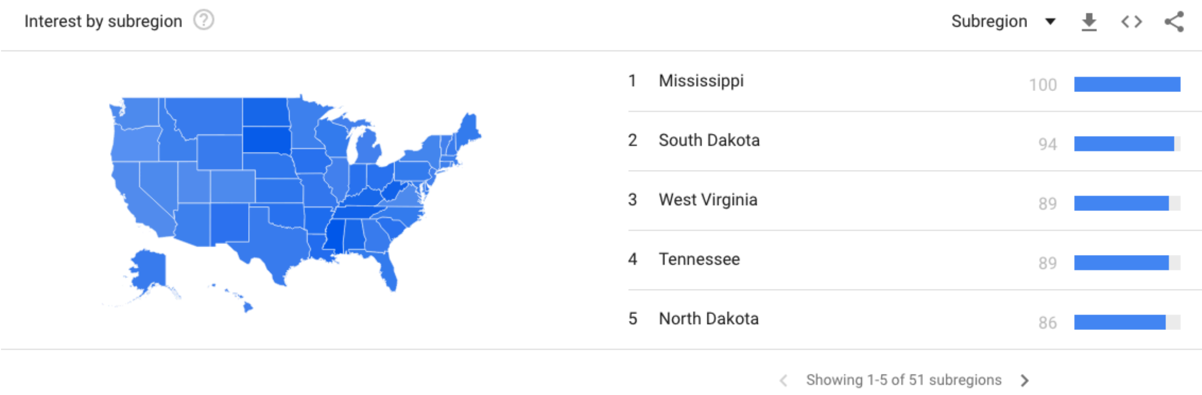

Figure 20: Online Search interest in the term "nurse" in the U.S. in 2004–2018

Conclusion

In the time of big data, AI, and the digital economy, statistical thinking has evolved from traditional question-then-answer analysis, where we ask questions and then collect and analyse data to arrive at a conclusion that we can use to make decisions. Now, we should use a more disruptive and creative approach, which starts with data-based answers derived from the examination of opportunistic data or data that just happens to be available in electronic form because it was accumulated by other people for other reasons, and then works backwards to find the questions that should have been asked.

In this scenario, previous frameworks of statistical thinking, such as the PPDAC cycle, are not appropriate to explain the richness and complexity of thinking involved in real-world statistical investigations dealing with big data. In that regard, we developed a new framework for statistical thinking comprising five phases or cognitive processes (i.e., patterns and relationships from data, questions, objectives, data mining, and designing) in order to appropriately describe how a person engages in statistical thinking when handling big data. An exemplar application of the framework illustrated the richness and complexity of thinking involved when handling big data from ***Google Trends,*** exploring issues related to population aging by checking the worldwide trend of web searches for terms such as "social security" and "nursing home" focusing on APEC member countries. From this application, it was possible to identify countries with similar and contrasting characteristics and classify APEC member countries based on such characteristics.

Although we have illustrated our proposed new framework for statistical thinking with an exemplar application, issues regarding how we can incorporate core ideas related to big data for the digital economy into the high school curriculum of each APEC member country, as well as what plausible instructional activities (i.e., exemplar applications) can be designed for teaching the fundamental ideas of statistics while fostering statistical thinking when handling big data, are expected to be fundamental outcomes of the discussion of the current document among all of the participants of the APEC-Tsukuba International Conference 2019 held at the University of Tsukuba Tokyo Campus (http://www.criced.tsukuba.ac.jp/math/apec/apec2019/).

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Mathematics Education for Future-Ready Learners: A Singapore Experience

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Abstract

This article presents the readers an alternative paradigm of teaching students mathematics not through the usual textbook approach but using comics and the related pedagogies. The author argues that it is more useful to equip students with the skills to acquire knowledge by using contexts that they are likely to encounter in the future. The author further continues with the research experience in Singapore in using comics in teaching mathematics. The approach began with the low-scoring students in mathematics, and it is argued that there is room for extending this method to other groups of students.

Keywords: Mathematics teaching, Singapore, innovative pedagogy

Introduction

Equipping students with the knowledge and skills necessary for adult working life is no longer a suitable paradigm for teacher education today, as the world is changing very quickly. The span of certain fields of knowledge is increasing at an exponential rate, and what is learned today may be quickly made obsolete by new technologies. The way a student understands the world today is so much diffe ent from a decade ago. Projecting into the future, the way a student of the future understands the world is beyond our imagination at present. For example, calculating one's position on the surface of the Earth by assuming it is a sphere has been made irrelevant by the use of the Global Positioning System (GPS). It is thus necessary to reconsider our paradigm of teacher education as one that prepares students to be future-ready.

Threat versus Opportunity

Worldwide educational programmes have evolved into more theory- than skill-based programmes, and most instructional programmes tend to have an advantage for students who are visual and audio learners (Glass, 2003). Students whose learning styles are classified as “kinesthetic” tend to lose out in such educational programmes and are more often than not classified as “low attainers” (Amir and Subramaniam, 2007 and Rayneri, et al., 2003).

A purely theory-based education programme might not be sufficien to equip students for the unknown future. For example, the world today combines and presents information and knowledge in diffe ent forms, including visual cues, rather than in textbook format. For example, when I was presenting to a group of high school mathematics students a combinatorics problem involving “dictionary order” of arranging a series of letters, everyone was stunned because they have never used a dictionary before! Any information they need, they retrieve online via a search engine or ***Wikipedia***.

Teachers’ day-to-day experience with students also shows that most of the so-called “low attainers” in school are “street-smart” individuals who can decipher information in the real world better than high achievers in school. As such, teachers could view this as an opportunity to close the gap between students of diffe ent achievement levels. In the remaining part of this article, I will discuss an effo t in Singapore for mathematics education that aims to prepare students to be future-ready, beginning with a trial with low-scoring students through an innovative pedagogy of using comics for mathematics instruction.

A Singapore Experience: Start with Low-Scoring Students

A survey was conducted by Toh and Lui (2014) on how Singapore teachers attempted to address the learning needs of their low-scoring mathematics students. They found that the teachers were very concerned with the mathematics learning of their low-scoring students despite the fact that Singapore performs very well in the ***Trends in International Mathematics and Science Study (TIMSS)*** and PISA. In an effo t to help students cope with mathematics, there was a great deal of effo t, though not well-coordinated, among mathematics teachers to devise their own creative teaching approaches to improve student performance. Among the many teaching approaches, storytelling, comics, and cartoons were used by the teachers for mathematics instruction. After this survey, I assembled a team of researchers from the Singapore National Institute of Education to propose a research project that introduced using comics for mathematics instruction for low-scoring students. We worked with three Singaporean mainstream schools. We eventually scaled up the study to 11 schools in total.

We began the whole process by designing sets of comics for selected mathematics topics from the lower secondary mathematics curriculum. As the research attempted to study the impact of comics on student learning and analyse the features of a comics-based mathematics lesson, we requested the participating schools to use the comics teaching package as an alternative for current resources. In other words, the comics teaching package should be used as a “replacement unit” (Leong, et al., 2018).

In designing our comics teaching package, we developed the following items:

- The sets of comic strips were chosen to cover all of the mathematical concepts for the selected topics. We replaced most of the standard textbook content and showed examples via comic strips with story lines that explained concepts within the context of the comics. These story lines were infused with contexts that the Singapore students were particularly familiar with (e.g., great Singaporean sales, the cultural heritage of Singapore, etc.). In addition, the comics packages were presented in two forms—hard copy version (where the students were given a printed copy of each comic book) and online version (where the students were provided with a password to log in to the platform). After the first cycle of implementation, we developed a parallel set of comics, where the readers were given an opportunity to complete the story by filling in blanks in comic strips. According to some teachers, they preferred that their students complete the story on the hard copies instead of passively listening to stories told during lessons.

- Each set of comics was accompanied by practice questions for teachers to reinforce the acquisition of mathematical concepts. These practice questions consisted of those within the context of the comics, questions from a similar context, and the typical examination-type questions. We wanted to ensure that the students had sufficien practice with the questions and, more importantly, that they were able to apply the knowledge they acquired across various contexts.

- We also included classroom activities that promoted the development of higher-order thinking skills (HOTS) among students. These questions stretched student thinking beyond the lower level tasks of understanding and application. In addition, we included open-ended tasks for students to use creativity to extend their understanding of mathematics.

- In addition, we provided a set of suggested lesson outlines, where we proposed how the lesson could be conducted using the comics package. In the first draft of this set of lesson outlines, we proposed storytelling as the underlying pedagogy to conduct lessons using the comics package. However, as we observed the lessons of many teachers, we saw that they included many good practices, which we eventually included in the outlines for the second and subsequent cycles of implementation.

Observations

We (Toh, Cheng, Ho, Jiang, and Lim, 2017) presented our observations from a mathematics lesson presented by a pair of teachers from a particular mainstream school. This was our first attempt to understand how a mathematics lesson using comics could possibly ensue and what its features were. We attempted to use the framework of the 21st-century competency (21cc) model suggested by the Singapore Ministry of Education (MoE) (see Figure 21).

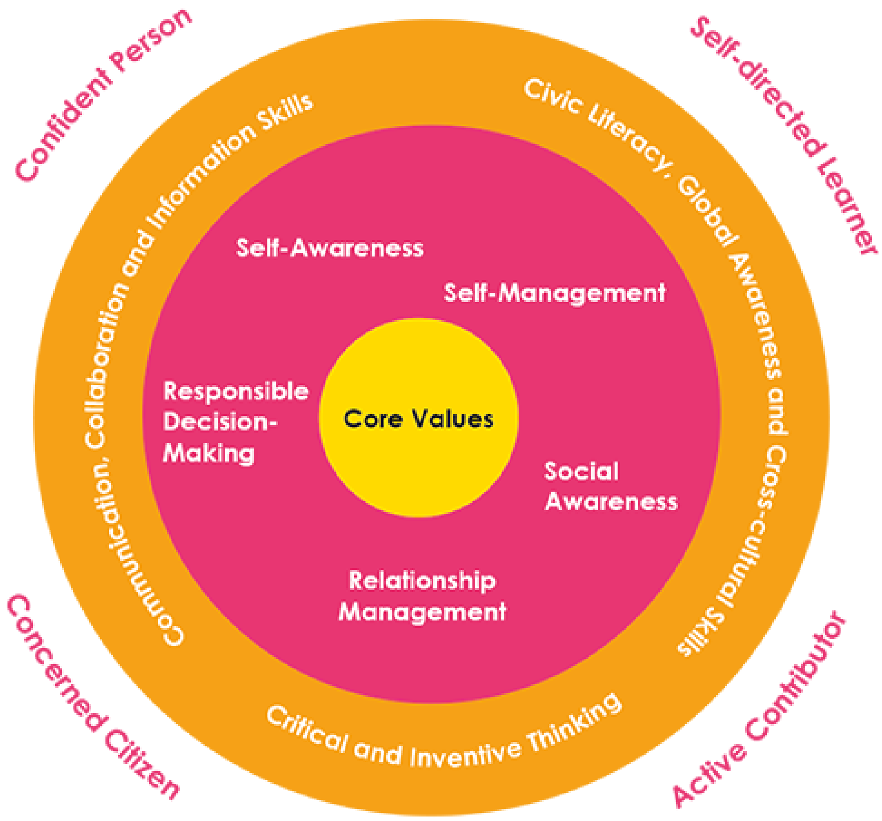

Figure 21: 21cc framework

We reported in Toh, et al. (2017) that the teachers seized every opportunity provided by the comics to engage students in mathematical discourse. There were several instances where the teachers attempted to use visual cues from the comics to invite students to decipher the meanings of visual codes and interpret the context of the story lines of the comics. The teachers also infused various elements of civic literacy and global awareness into their lessons. The interview conducted with the students showed a positive gain in various soft skills that form part of the elements of Singapore's 21cc framework. Interested readers are encouraged to read the article for more details.

We (Toh, Cheng, Lim, and Lim, 2018) further attempted to observe the comics mathematics lessons of several other teachers. We saw that the comics mathematics lessons did not merely involve passive learning, comics reading, or monotonous narrating of the story by the teachers (as we earlier proposed in the first draft of the lesson proposals). The teachers seized the opportunity to engage students in active learning. The students in these classes were actively engaged in mathematics discourse during the lessons. In particular, the teachers engaged their students in role-play to reenact the entire story line of the comics with various students playing fictitious characters. The other students actively participated by asking and answering questions during the interaction with the fictitious characters. Not only that, the teachers also engaged students to participate in constructing the story by using comic strips with partially removed dialogues.

All of the observations above led us to further fine-tune our proposed lesson outlines for the subsequent implementation of the comics research project. As such, our research went through cycles of design, implementation, and fine-tuning, as shown in igure 22.

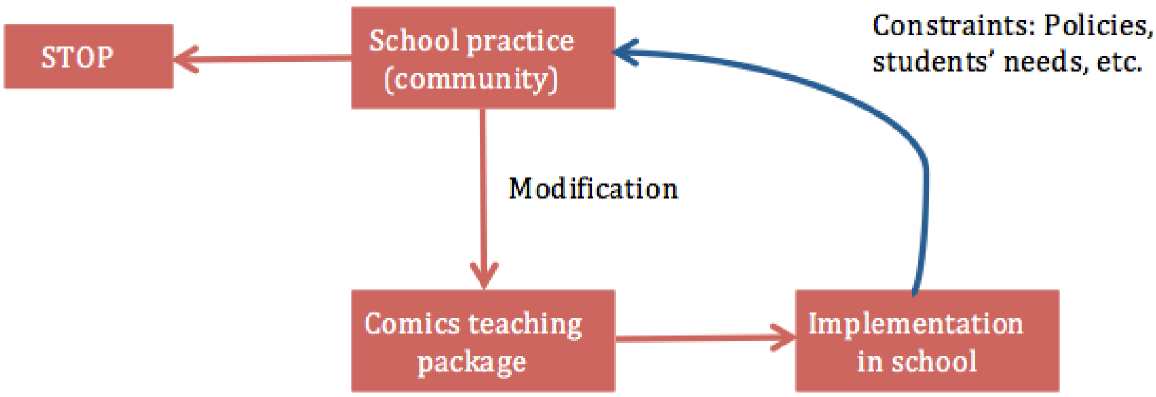

Figure 22: Design cycle of the comics research project

Next Step

As the research went on, we received interest from various schools in duplicating the programme for upper primary- and secondary-level students. According to the feedback given by interested teachers, the design of the comics project was suitable not only to motivate the unmotivated but also to prepare students to acquire knowledge beyond textbooks, that is, from a real-world context. Mathematics educators are moving away from heavily worded mathematical problems to situations that involve a combination of diffe ent representations of information that usually involve a combination of graphics and words (Lowrie, 2012). Thus, it is not an exaggeration to say that the use of comics in education could reach an unprecedented status in preparing students for literacy in the future world.

Acknowledgement

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Suggesting Inter-disciplinary Teacher Education for the Fourth Industrial Revolution: A Korean Perspective

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Abstract

This article aims to present a new direction for teacher education in Korea to develop teachers' competencies to foster "convergence" and "creativity," which are crucial for making the Fourth Industrial Revolution sustainable. It introduces "inter-disciplinary teacher education" that is being pursued in recent years by the Korea National University of Education. After reviewing the educational challenges to prepare for dramatic social changes brought on by the revolution, the activities of the Convergence Education Research Center and Future Education Experience Center of Korea National University will be presented. Finally, the international cooperation programme and five-year training course that the university plans to implement in the long term will be proposed as a necessary strategy to realise inter-disciplinary teacher education.

Keywords: Teacher education, Korean education Challenge, Fourth Industrial Revolution

Current Issues in Education

The Fourth Industrial Revolution refers to the recent industrial transformation based on a range of new technologies like AI, VR, the Internet of Things (IoT), and self-driving cars that intelligently connect machines and humans through a high-speed fifth-gene ation mobile (5G) network (Schwab, 2017). It is the revolution that will cause dramatic changes not only in industries but also in our everyday lives through the fusion of ultramodern technologies. In the new society, education also faces new challenges that are quite diffe ent from what we have seen so far (Ryu, 2020).

In this society, a converging aptitude is believed to be one of the most important concepts in the educational arena that must be turned into a habit because the Fourth Industrial Revolution requires convergence (MoE, 2015). In that sense, we need to teach students about the connections and complex relationships between humans and machines, which will change how we think and live, rather than teach them to just understand and utilise fragmentary knowledge. Furthermore, education should provide comprehensive social information beyond what traditional subject matters teach so that students can cope with the rapid changes in the job market. The Fourth Industrial Revolution urges us to change certain areas in education, such as:

- Add a converging aptitude to curricular activities
- Discuss the complex relationships between humans and machines
- Include comprehensive social information in lessons to go beyond learning from traditional subjects

Technology has allowed AI systems to take charge of many things that only human beings were capable of in the past (MoE, 2019). Education should thus focus on developing soft skills, such as social ability, sensitivity, empathy, passion for adventure, and networking, along with cognitive skills such as critical thinking and problem solving. Also, as the social structure changes so rapidly that schools cannot affo d to be in charge of all education, students need to master the ability to learn on their own from the surrounding communities. To sustain the Fourth Industrial Revolution, it is important to train students to attain new kinds of skills that include:

- Cognitive skills, such as critical thinking, creativity, and problem solving
- Soft skills, such as being passionate about adventure and networking
- Self-learning from the surrounding world

The Korean government provides core competencies that curricula should include, such as self-management, information processing, creative thinking, aesthetic sensibility, communication, and community competency (MoE, 2015). All of these six abilities are closely related to connectivity, which is a crucial concept in the Fourth Industrial Revolution, as shown in Table 5.

Goal	Description	Connectivity
Self-management	Ability to self-direct to carve one's future life and career	Connection between students and their future lives as a job acquisition strategy
Information processing	Ability to process information in various areas to solve problems reasonably	Connection among various pieces of information as a problem-solving strategy
Creative thinking	Ability to create new things by converging knowledge, skills, and experiences in various field	Connection between knowledge, skills, and experiences as a tool for creation
Aesthetic sensibility	Ability to discover the meaning and value of life based on a sympathetic understanding of human beings and a sense of cultural sensibility	Connection between life and culture as a tool to appreciate the meaning and value of life
Communication	Ability to effectively xpress one's thoughts and feelings in various situations	Connection between humans as a tool to understand each other
Community competency	Ability to actively participate in community development with the values and attitudes required by members of local, national, and global communities	Connection among students and various members of the society as a tool to live together

Table 5: Curriculum goals to realise connectivity, a key concept in the Fourth Industrial Revolution

In order to sustain the Fourth Industrial Revolution, it has long been argued that educational

Current Issues in Teacher Education

methodologies should be integrated rather than compartmentalised, as they are now (MoE, 2011, 2012, 2015a, and 2015b). Convergence education should foster students who can communicate diffe ent ideas and perspectives to their colleagues and synthesise diffe ences with an open mind (MoE, 2019). Students need to understand that society, nature, and the world should be all connected organically, and basic knowledge of humanities, social studies, science, art, and technology should be cultivated in a balanced and integrated way. For such education, it is necessary to guide students to compare and connect various knowledge and appreciate situations, contexts, and preconditions where knowledge is made rather than teach them isolated knowledge in a systematic way.

However, there have been no serious debates on how to train teachers who will comprehensively manage classrooms. At present, the teacher education system trains teachers with a compartmentalised viewpoint of each subject like mathematics, English, or science under a department that is very similar to the school system in structure. If we view the Fourth Industrial Revolution as an age of convergence, the current compartmentalised teacher education system should change. We still train "old-style teachers" for uniform education, which was appropriate for the previous Third Industrial Revolution era. The uniform education was to mass-produce "good workers" with basic skills and knowledge to propel economic development quickly, rather than with creativity required in the era of the 4th industrial revolution.

A New Vision of Korea National University of Education for Teacher Education

The Korea National University of Education is the country's only comprehensive teacher training institution. It trains all pre-service kindergarten to high school teachers and provides almost all kinds of in-service training programmes. It is also responsible for the nation's new principal training and mentor teacher qualification p ogrammes.

To train education experts to become creative leaders in line with the advent of the Fourth Industrial Revolution, the Korea National University of Education proposed six major competencies as new educational goals—humanity in community (H), integrated intelligence (I), globalisation (G), harmony in school (H), experience in classroom (E), and renovation (R), which can be summarised by the acronym "HIGHER."

6 Visions	Acronym	Description
Humanity in community	H	Teacher as a social leader with the personality to coordinate interpersonal relationships
Integrated intelligence	I	Teacher as a classroom specialist with a STEAM perspective
Globalisation	G	Teacher as a global leader with an international perspective
Harmony in school	H	Teacher as a school leader with a sense of empathy in communicating with colleagues, students and parents
Experience in classroom	E	Teacher as a classroom manager with field xperience
Renovation	R	Teacher as an educational innovator with an eye for the future education environment

Table 6: A new vision for Korea National University of Education

In order to realise this vision, the Korea National University of Education carried out a total of 62 projects from 2017 in seven areas with the support of the government's ACE+ Fund for universities with "excellent undergraduate education development plans."

Area	Projects
Liberal arts curriculum revision	10 projects, including "Community, Personality, and Culture"
Major curriculum revision	8 projects, including "Developing VR Content"
Non-subject matter curriculum revision	8 projects, including "Education Donation and Overseas Volunteer Work"
Improved academic management system	4 projects, including "Intensive Course System"
Improved student guidance system	10 projects, including "Community Development and Student Guidance"
Area	**Projects**
Improved teaching support system	10 projects, including teaching and learning support programmes
Improved education quality control system	12 projects, including "Cultural and Major Education" and reorganising the centre for reverse education

Table 7: Korea National University of Education ACE+-funded projects to realise its vision

Convergence Education Research Center

To present a new paradigm of convergence education for the cultivation of Human Resources required by the future society and nurture teachers capable of cultivating convergent talents, the Convergence Education Research Center was established by the Korea National University of Education in 2016. The centre will be responsible for several areas discussed below.

Convergence Teacher Education Programme

The centre develops a variety of convergence teacher education programmes to strengthen the convergence capacity of pre-service teachers and conduct various activity-oriented convergence education projects to help them develop various contents on their own when they graduate.

Mentoring System for Pre-Service Teachers

The centre runs a mentoring system in cooperation with the National Council of Mentor Teachers, focusing on managing classes. If there is a request for a training course from each department, the centre invites proper mentor teachers who have previous experience in convergence education as a tutor or a consultant for the department.

Festivals, Forums, and Workshops

The centre hosts festivals, forums, and workshops, where students and teachers participate to spread convergence education nationwide and improve teachers' job guidance skills for junior and senior high school students.

Policy Design for MoE

The centre suggests various policies to support convergence education and plays a role in advising MoE's provincial education offices and school

Convergence Education Student Programme

The centre develops convergence education programmes that can be used in K-12 schools and collects responses from the field about whether teachers have realised a positive change in students' convergence capabilities or not.

Future Education Experience Center

Facilities are necessary to enhance pre-service teachers' convergence capabilities through activities related to the Fourth Industrial Revolution. At present, there are many Maker Spaces and FAB Labs that serve as various convergence education facilities across the country. However, most of them are for young entrepreneurs and engineering college students rather than pre- and in-service teachers.

The Korea National University of Education plans to establish the "Future Education Experience Center" to improve the educational convergence capacity of pre- and in-service teachers. This centre consists of three main areas—a future career experience zone, a future educational environment zone, and a maker zone.

Future Career Experience Zone

This consists of career inspection, consultation, and experience rooms as spaces to foster teachers' career guidance capacities and support students' own career designs, as the occupational world rapidly changes in the Fourth Industrial Revolution.

Future Educational Environment Zone

This is a space that provides an opportunity to understand, experience, and utilise advanced technologies to enhance the future education capabilities of pre- and in-service teachers. It is an advanced technology exhibit and experience space that visitors can access and functions as a testbed for edu-tech businesses.

Maker Zone

This consists of a maker lounge, a prototype room, a wood design room, an art design room, a software room, and a support room to promote the "maker space movement" and present a standard model for maker space education in the community and the public sector.

International Exchange and Cooperation

As Charles Dickens, a British novelist during the Victorian Age said in one of his novels, “The best and the worst, wisdom and foolishness, faith and doubt, light and dark coexist when revolution rises.” Cooperation among scholars and teachers in various fields to open their minds and have serious and keen discussions is the only way not to move in the wrong direction. The Convergence Education Research Center has been pursuing international cooperation with the LUMA Center of Helsinki University and UPI in Indonesia for the past three years now. Shortly, it will expand and continue international cooperations to exchange ideas about convergence education with South America and Southeast Asia, specifically with the University of Chile, Khon Kaen University, University of Philippines, Vietnam National University of Education, SEAMEO Regional Centre for Education in Science and Mathematics (RECSAM), SEAMEO QITEP in Mathematics, SEAMEO QITEP in Science, SEAMEO Regional Centre for Educational Innovation and Technology (INNOTECH), and other institutions.

Establishment of a Five-Year Teacher Education Plan

The current four-year teacher training system has many problems in training teachers capable of linking and integrating curricula. That is due to a short education period to build diverse knowledge and experiences necessary for convergence education that goes beyond the content of one curriculum. Also, to train interdisciplinary teachers, eight weeks of practical teaching in the current system must increase to more than 15 weeks. A minimum of five years of teacher training is required to develop a teacher who can take on convergence education. An additional one-year course can be used to foster one’s ability to design an integrated curriculum that promotes practical convergence capabilities and gives way to various heuristic convergence education experiences. The Korea National University of Education is closely consulting with MoE and provincial education office to change teacher education into a five-year course af er revising related laws.

Conclusion

The Fourth Industrial Revolution will bring about an unprecedented kind of social change in that it is based on super connectivity that is incomparable to the previous era. Super connectivity will usher in a new era that connects human to other human, human to machines, and machines to other machines. As such, education should also differ f om that in the previous revolution era.

In the new society, nurturing figu es like Steve Jobs, who has an innovative mind and artistic design sense, in school is necessary. We need good teachers to realise convergence education. We need to move away from the “uniform education” that the government and the society have been implementing since 1960-70 to match the requirements of the Third Industrial Revolution led by computer information processing and automated production systems. We have only been training students to become “good workers” with basic skills and knowledge, rather than creative ones that the Fourth Industrial Revolution needs. Times are changing. Given that the quality of education does not exceed teachers’ qualifications, it is time for us to become epistemologically and methodologically aware of the new kind of teacher education.

Acknowledgement

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Supporting Reforms and Developments in Teacher Education for the Digital Economy

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Abstract

Teacher education reforms and developments in the Philippines may be viewed in relation to the country's continuous pursuit of teacher quality. As such, they should be supported. An example of these is the Philippine Professional Standards for Teachers (PPST) which define teacher quality in the country. The Department of Education (DepEd) Teacher Education Council (TEC) published the ***Philippine Professional Standards for Teachers (PPST)*** in 2017. The standards were developed through the Research Center for Teacher Quality. Supporting the PPST entails providing support to teachers so that they can meet the requirements of the Standards.

This article presents the support initiatives of UP NISMED that address specific domains and strands in the standards. These interrelated domains include content knowledge and pedagogy, curriculum and planning, and personal growth and professional development. The kind of support that UP NISMED extends through its various programmes and projects address these domains and strands simultaneously.

Keywords: Teacher education, digital economy, educational reform, Philippines

Introduction

Reforms and developments in teacher education in the Philippines may be viewed in relation to the country's continuous pursuit of teacher quality. In 2017, DepEd TEC published the ***PPST***, which was developed through the Research Center for Teacher Quality. These standards define teacher quality in the Philippines. They describe expectations from teachers in terms of increasing levels of knowledge, practice, and professional engagement. In particular, they play an important role in ensuring that the K–12 curricular reform will achieve its goals. For the reforms and developments relative to the standards to be effective, suppo t mechanisms should be put in place.

UP NISMED's main functions are research, curriculum development, and teacher professional development in science and mathematics education at the basic and teacher education levels. Hence, its programs and projects provide support to teachers particularly in relation to the Standards' domains of content and pedagogy, curriculum and planning, and personal growth and professional development.

Teacher professional development is a lifelong learning process that spans a continuum, where teachers move from being beginning teachers to proficient ones. They then move on to becoming highly proficient teachers and finall , to distinguished ones. The qualities of teachers in these diffe ent career stages are detailed in the appendix. This article will focus on the support that UP NISMED provides to teachers so they can espouse the characteristics of highly proficient p ofessionals.

Diffe ent PPST Domains that UP NISMED Supports through Various Initiatives

Domain: Content Knowledge and Pedagogy

> "*This domain recognizes the importance of teachers' mastery of content knowledge and its interconnectedness within and across curriculum areas, coupled with a sound and critical understanding of the application of theories and principles of teaching and learning. It encompasses teachers' ability to apply developmentally appropriate and meaningful pedagogy grounded on content knowledge and current research. It takes into account teachers' proficiency in Mother Tongue Filipino, and English in the teaching and learning process as well as needed skills in the use of communication strategies, teaching strategies, and technologies to promote high-quality learning outcomes.*"
>
> —PPST, *2017, p. 10*

Strand	Highly Proficient Teacher
Content knowledge and its application within and across curriculum areas	Model effective applications of con ent knowledge within and across curriculum teaching areas
Research-based knowledge and principles of teaching and learning	Collaborate with colleagues in the conduct and application of research to enrich knowledge of content and pedagogy
Positive use of ICT	Promote effective st ategies in the positive use of ICT to facilitate the teaching and learning process
Strategies for promoting literacy and numeracy	Evaluate with colleagues the effectiveness of teaching strategies that promote learner achievement in literacy and numeracy
Strategies for developing critical and creative thinking, other higher order thiniking	Develop and apply effective eaching strategies to promote critical and creative thinking, and as well as other higher order thinking skills

Table 8: Domain: Content knowledge and pedagogy standards (***PPST***, 2017, pp.10–11)

Domain: Curriculum and Planning

"This domain addresses teachers' knowledge of and interaction with the national and local curriculum requirements. It encompasses their ability to translate curriculum content into learning activities that are relevant to learners and based on the principles of effective teaching and learning. It expects teachers to apply their professional knowledge to plan and design, individually and in collaboration with colleagues, well-structured and sequenced lessons. These lesson sequences and associated learning programmes should be contextually relevant, responsive to learners' needs, and incorporate a range of teaching and learning resources. The Domain expects teachers to communicate learning goals to support learner participation, understanding, and achievement."

—**PPST**, *2017, p. 16*

Strand	Highly Proficient Teacher
Planning and management of teaching and learning process	Develop and apply effective st ategies in the planning and management of developmentally sequenced teaching and learning process to meet curriculum requirements and varied teaching contexts
Learning outcomes aligned with learning competencies	Model to collegues the setting of achievable and challenging learning outcomes that are aligned with learning competencies to cultivate a culture of excellence for all learners
Professional collaboration to enrich teaching practice	Review with collegues, teacher and learner feedback to plan, facilitate, and enrich teaching practice
Teaching and learning resources including ICT	Advise and guide colleagues in the selection, organization, development, and use of appropriate teaching and learning resources, including ICT, to address specific learning goal

Table 9: Domain: Curriculum and planning standards (***PPST***, 2017, p. 16 - 17)

Domain: Personal Growth and Professional Development

"This domain focuses on teachers' personal growth and professional development. It accentuates teachers' proper and high personal regard for the profession by maintaining qualities that uphold the dignity of teaching, such as a caring attitude, respect, and dignity. It values personal and professional reflection and learning to improve practice. It recognizes the importance of teachers assuming responsibility for personal growth and professional development for lifelong learning."

—**PPST**, *2017, p. 22*

Strand	Highly Proficient Teacher
Philosophy of teaching	Manifest a learner-centered teaching philosophy in various aspects of practice and support colleagues in enhancing their own learner-centered teaching philosophy
Professional links with colleagues	Contribute actively to professional networks within and between schools to improve knowledge and enhance practice
Professional reflection and learning o improve practice	Initiate professional reflections and p omote learning opportunities with colleagues to improve practice

Table 10: Domain: Personal growth and professional development standards (***PPST***, 2017, p. 22)

UP NISMED's programmes and projects that address the foregoing domains include the Collaborative Lesson Research and Development (CLRD) Programme, the Go Teacher Go! Radio Programme, the

Support Initiatives of UP NISMED

GeoGebra Institute of Metro Manila @UP NISMED website, the Ag/Mat website, and the KaSaMa Teachers Online Community.

CLRD Programme

This programme uses lesson study to promote teaching science and mathematics through inquiry and problem solving, respectively. According to Wang-Iverson and Yoshida (2005), in lesson study, teachers aim to enhance their students' learning experiences and their own teaching by collaboratively and systematically carrying out research on classroom teaching and learning. They describe lesson study as a model of a long-term professional learning led by teachers that was developed in Japan. Teaching science through inquiry and teaching mathematics through problem solving are learner-centered teaching approaches in that they provide plenty of opportunities for students to engage in creative, critical, and other high-level thinking, as they learn science and mathematics content.

In doing lesson study, which is based on the theory of social constructivism, UP NISMED specialists collaborate with schoolteachers to formulate their research theme or long-term goals and yearly subgoals or lesson study goal for the long-term development of their students through the improvement of their teaching. Once the goals are set, they plan the unit to which the research lesson that will help them achieve their goals belongs. In developing the research lesson, whose objectives are aligned with the research theme and lesson study goal, the lesson study team critically examines the curriculum—its scope and sequence, learning competencies and standards, textbooks, teachers' guides, research studies on the topic of the lesson, students' assessment results, and other relevant materials and ideas. They also discuss their own experiences with and learnings from their previous teaching of the topic. They write the research lesson plan then one of the teachers in the team implements it in his/her own class. The rest of the team members, along with other invited observers, such as teachers of the same subject but in diffe ent grade levels, gather data through observation when the lesson is implemented. These data serve as the basis of their discussion in the post-lesson reflection and discussion (PRD) in relation to the research theme, lesson study goal, and the objective of the lesson focusing on student learning and thinking. Then the research lesson is revised based on the results of the PRD and implemented by another teacher in the team in his/her own class. This is followed by another PRD, after which the lesson study team writes its report. Figure 23 shows the lesson study process that is followed in the CLRD Programme.

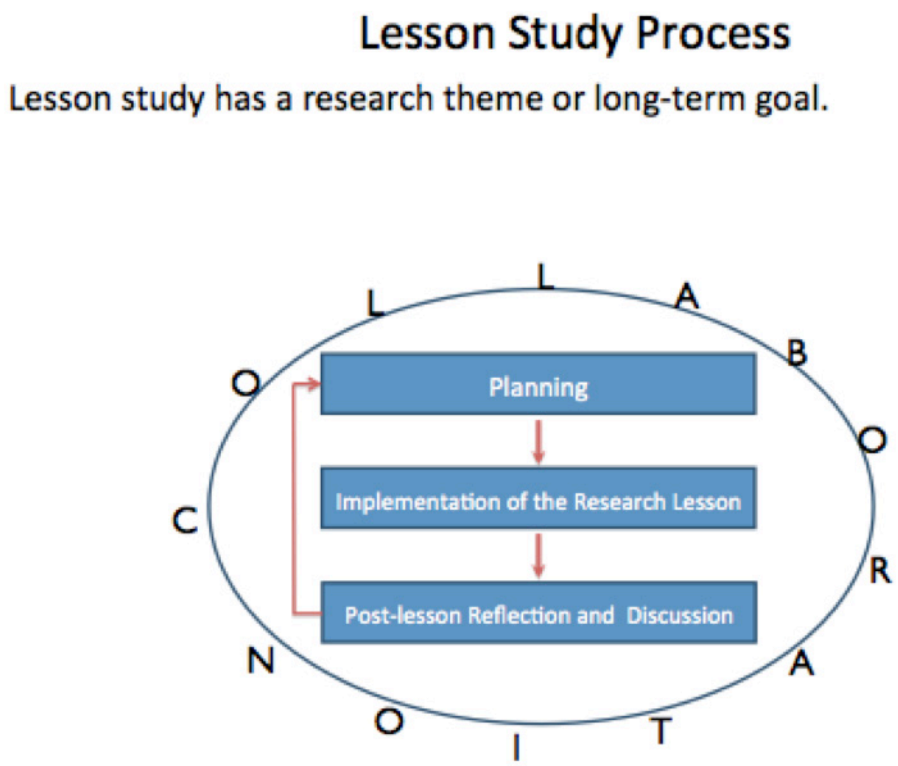

Figure 23: Lesson study process

Examples of accounts that show that teachers' knowledge of content was deepened and broadened and their pedagogy gradually shifted to making students more responsible for their own learning are documented in the two lesson study books that UP NISMED published as well as in its dedicated lesson study website (see Figure 24). These and the ***Lesson Study Guidebook*** it published support teachers as they develop a mindset to collaborate with one another so they can grow professionally and enrich the learning experiences of their students. These resources are also used by education graduate students for their research on lesson study.

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Figure 24: Lesson study books that UP NISMED published and its dedicated lesson study website

UP NISMED also conducts professional development programmes with two phases, which are sponsored by various sectors. These programmes often include several schools in a district, city, or province. The first phase is a training programme, which familiarises the participants, consisting of teachers, subject coordinators, principals, supervisors, and teacher educators, with teaching approaches that are inquiry-based in science and problem-solving-based in mathematics and lesson study as a teacher professional learning process. The second phase is a school-based follow-through, where UP NISMED specialists observe teacher participants as they implement research lessons in their own classes. They collaboratively developed the lessons based on their research theme and lesson study goals. These programmes provide opportunities for schoolteachers and university teacher educators to collaborate. The latter serve as knowledgeable others both in the planning and PRD stages of lesson study.

The Philippine Association of Lesson and Learning Studies (PALS) is an organisation initiated by UP NISMED that aims to promote lesson study and create a network of lesson study practitioners in the Philippines to improve the quality of education. So far, PALS has organised seminars and workshops on lesson study and related topics in diffe ent schools throughout the country. These were conducted by experts from Japan, UP NISMED specialists, and collaborating schoolteachers.

Go Teacher Go! Radio Programme

Go Teacher Go! is a radio programme produced by UP NISMED in cooperation with DZUP 1602, the officia amplitude modulation (AM) radio station of UP. The programme provides useful information for elementary and high school teachers on science and mathematics and strategies to teach them. Episodes also address common student misconceptions, difficulties and errors as well as numeracy and scientific literacy. Besides UP NISMED specialists, invited resource persons include schoolteachers, university professors, and experts in diffe ent fields of science and mathematics. By participating in the live-streamed programmes or listening to podcasts, teachers can acquire a better understanding of content and pedagogy and appreciate its applications in their teaching practices.

GeoGebra Institute of Metro Manila @UP NISMED

GeoGebra is a free downloadable dynamic mathematics software. UP NISMED developed mathematical tasks such as applets in GeoGebra, which can be used for problem solving or mathematical investigations. These resources, which are found at https://geogebra.nismed.upd.edu.ph emphasise understanding of concepts and mathematical thinking. Figure 25 is an example of an app using GeoGebra.

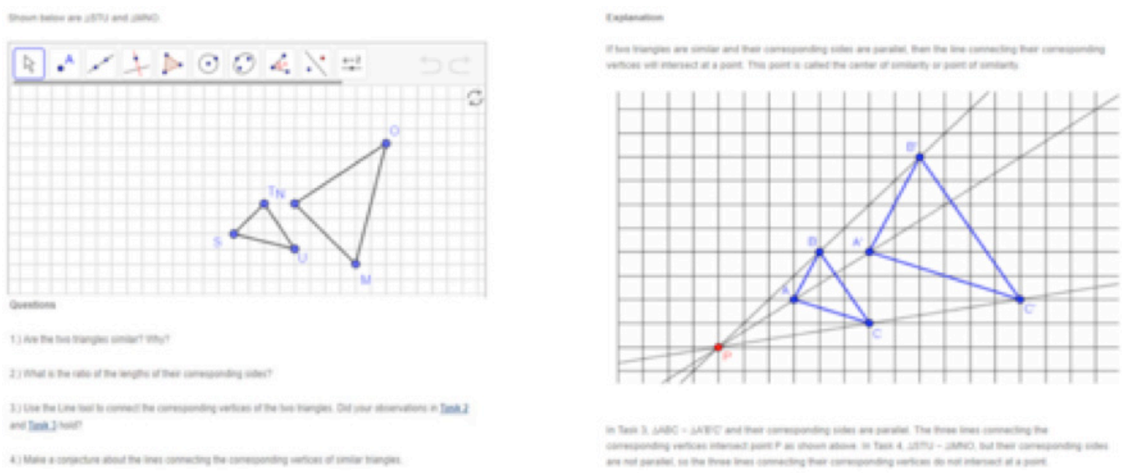

Figure 25: An example of using GeoGebra to investigate similar triangles

AgIMat Website

In Ag/Mat, "Ag" stands for "agham" (i.e., the Filipino word for "science"), "/" stands for "impormasyon" (i.e., Filipino for "information"), and "Mat" stands for "mathematics." The website contains tried-and tested teaching and learning resources, which include, among others, lesson plans, activity sheets, and tasks for mathematical investigations. It provides teachers examples of the positive use of ICT and ICT-mediated teaching and learning resources for enhancing their own and their students' learning.

KaSaMa Teachers Online Community

Teachers from diffe ent schools, educators from diffe ent teacher education institutions (TEIs), and UP NISMED specialists who are members of the KaSaMa Teachers Online Community share teaching and learning resources; interact with one another regarding their practices, challenges, and solutions; and collaborate on common professional development activities. Webinars are also conducted mostly by UP NISMED specialists to share critical information, materials, and updates to support teachers, for example, in implementing the new science curriculum or adapting lesson study in their schools.

Figure 26: KaSaMa Teachers Online Community website

Conclusion

The support initiatives of UP NISMED concerning reforms and developments in teacher education involve the enhancement of teachers' competence in teaching by strengthening their content and pedagogical content knowledge, research skills, and professional development in collaboration with other colleagues. These are accomplished through face-to-face undertakings, such as those held in training venues and/or schools. They are achieved as well through the use of technology, which is prevalent in today's digital economy. With technology, constraints related to time, space, distance, and finances, among others, which often hinder the effectiveness of reforms and developments, are addressed. Taken together, the support initiatives of UP NISMED help teachers meet the standards set forth by ***PPST***.

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Appendix

Career Stages of Teachers

The following are descriptions of the "elements of high-quality teaching for the 21st century" (***PPST***, 2017, pp. 7–9) across the diffe ent stages of a teacher's career.

Career Stages			
Stage 1: Beginner Teachers	**Stage 2: Proficient Teachers**	**Stage 3: Highly Proficient Teachers**	**Stage 4: Distinguished Teachers**
They have gained the qualifications ecognised from entry into the teaching profession.	They are professionally independent in applying skills vital to the teaching and learning process.	They consistently display a high level of performance in their teaching practice.	They embody the highest standard for teaching grounded on global best practices.
They have a strong understanding of the subjects or areas for which they were trained in terms of content knowledge and pedagogy.	They provide focused teaching programmes that meet curriculum and assessment requirements.	They manifest an in-depth and sophisticated understanding of the teaching and learning process.	They exhibit an exceptional capacity to improve their own teaching practices and those of others.
They possess the requisite knowledge, skills, and values that support the teaching and learning process.	They display skills in planning, implementing, and managing learning programmes.	They have highly education-focused situation cognition, are adept in problem solving, and optimise opportunities gained from experience.	They are recognised as leaders in education, contributors to the profession, and initiators of collaboration and partnerships.
They manage learning programmes and have strategies that promote learning based on the needs of their students.	They actively engage in collaborative learning with the professional community and other stakeholders for mutual growth and advancement.	They provide support and mentoring to colleagues in their professional development and work collaboratively with them to enhance the learning and practice potential of their colleagues.	They create a lifelong impact in the lives of colleagues, students, and others.
They seek advice from experienced colleagues to consolidate their teaching practice	They are reflective practitioners who continually consolidate the knowledge, skills, and practices of Career Stage 1 teachers	They continually seek to develop their professional knowledge and practice by reflecting on their own needs and those of their colleagues and students	They consistently seek professional advancement and relevance in pursuit of teaching quality and excellence
			They exhibit commitment to inspire the education community and stakeholders for the imporvement of education provision in the Philippines.

Innovating Education in Response to the Opportunities and Challenges Related to the Digital Industry

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Abstract

We live in an era of globalisation where many of the things in life are handled by utilising technology. Globalisation has caused speedy changes that bring about shifts in knowledge, economy, and the Fourth Industrial Revolution. It also changes the workforce, which requires highly skilled workers. Some jobs will decline and new types of jobs are predicted to emerge in the near future. Southeast Asia, as a growing region with 11 nations, is also facing these challenges. All countries must together develop an education system that is forward-looking, future-oriented, and strategic to prepare today's youth to become a vital part of the digital economy through their education. Unfortunately, not all children are lucky to obtain proper education, particularly in the West Java province of Indonesia where the enrollment rate was very low. In 2014–2015, more than 200,000 students were unable to continue their education to finish high school. Starting in 2017, SEAMEO SEAMOLEC, in cooperation with the West Java Provincial Education Office developed models for an open high school and a distance learning vocational school. The main objectives of this programme are to improve access to and the quality and relevance of secondary education through a distance learning system in Indonesia, especially in West Java. This programme allows a learner to study by using an independent learning system that cooperates with businesses and industries by combining distance learning using an Internet-connected network, face-to-face learning, and practice with facilitators from business or industry practitioners. On a wider scope, this programme is expected to reduce unskilled labour.

Keywords: Distance learning, industrial revolution, secondary education, West Java

Introduction

The world is more globalised and becoming seemingly smaller due to the emergence of technology and its impact. We live in an era where anyone can connect with another across vast distances and many of the things in life are handled by utilising technology. Decision making by people, businesses, organisations, communities, and the government are commonly supported by technology now. This phenomenon has changed the way we live, communicate, and work, including how we implement technology in the field of learning

A student from Indonesia can easily interact and share interests with other students in the Middle East, Vietnam, or Mexico. Around the globe, all kind of individuals and groups are easily connected and no single crisis can slow down their activities, not even an economic crisis. Nairn (2009), in one of his articles, claimed that globalisation is such a diverse, broad-based, and potent force that not even today's massive economic crash will dramatically slow it down or permanently reverse it. Love it or hate it, globalisation is here to stay.

Industrial Revolution

Globalisation has caused speedy changes that brought about shifts in knowledge and economics and the Fourth Industrial Revolution. According to Xu, David, and Kim (2018), an industrial revolution is often considered a separate event and can be better understood as a series of events building upon innovations of the previous revolution and leading to more advanced forms of production. The First Industrial Revolution changed our lives and economy from agrarian and handicraft-based to one dominated by industry and machine manufacturing. Oil and electricity facilitated mass production in the Second Industrial Revolution. In the Third Industrial Revolution, IT was used to automate production. The Fourth Industrial Revolution now involves computer-generated product design and three-dimensional (3D) printing, which can create solid objects by building up successive layers of materials.

Arising from an Asian Development Bank (ADB) article (2017), the Fourth Industrial Revolution refers to a set of highly disruptive technologies, such as AI, robotics, blockchain, and 3D printing, which are transforming social, economic, and political systems and putting huge pressure on leaders and policy-makers to respond. It is easy to see the advantages of an industrial revolution. All technological aspects that made our life much easier, such as electricity, cars, or air-conditioning, are among the good impacts of a revolution.

Xu, David, and Kim (2018) further predicted that the opportunities that come with the Fourth Industrial Revolution include:

- Lower barriers between inventors and markets
- More active role for AI
- Integration of diffe ent techniques and domains (i.e., fusion)

- Improved quality of life (i.e., robotics)
- A connected life (i.e., Internet)

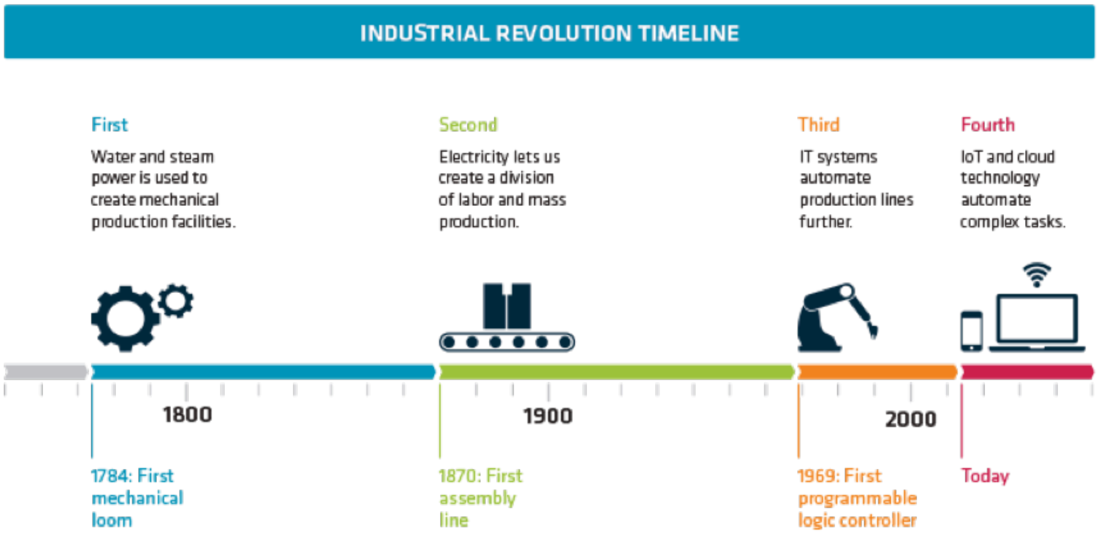

Figure 27: Industrial revolution time line

On the other hand, the Fourth Industrial Revolution also changed the workforce, which now requires highly skilled workers. It has affec ed some jobs, leading to a decline, and new jobs are predicted to emerge in the near future. Technologies today are being progressively used across diffe ent sectors. As such, education should adapt and reinforce learning, including learning at work, mentoring, vocational training, and community-based courses.

Challenges in Southeast Asia

Southeast Asia, as a growing region with 11 nations, is also facing challenges. The transformative impact of this revolution will demand that countries think deeply about their policies and priorities on a national scale. Southeast Asian countries must together develop an education system that is forward-looking, future-oriented, and strategic to prepare today's youth to become a vital part of the digital economy and digital citizens through. Unfortunately, not all children are lucky to obtain proper education. In one of his articles entitled "Challenges in Education in Southeast Asia," Sadiman (2004) mentioned that inequality in access to education in the region is one of many challenges. The problem exists due to some conditions that result in disparities in the delivery of quality learning opportunities. The following factors are main contributors to the problem:

- Lack of available school buildings and classrooms with all required facilities
- Shortage of teachers, especially in remote areas
- Uneven spread of the population

- Lack of good textbooks and other learning materials
- Geographical location
- Students' and parents' lack of appreciation for education
- Socioeconomic condition of the family
- Lack of budget for building more schools, classrooms, and learning facilities

Case Study in West Java, Indonesia

West Java, one of the provinces closest to Indonesia's capital, Jakarta, has a very low enrollment rate. In 2013–2014, the West Java education enrollment recorded a 10% gap from the target middle school enrollment volume. Some 247,067 students were not able to finish high school. In 2014–2015, the number of junior high school students reached 703,747 but only 469,567 graduated. As such, 234,180 students did not go on to high school.

To overcome the disparity in school capacity, the government of West Java, through the Offic of Education, implemented several excellent programmes, including new classroom development, new school unit establishment, afternoon school implementation, and the C Package Equality Programme. The results, however, still did not meet the target high school enrollment volume.

One of the big reasons is the physical capacity of secondary schools in West Java. There are other factors that cause the participation number in secondary schools to be less than expected. These include the low economic status of parents, the remoteness of student residences, and social and geographical difficulties that impede access o regular educational services.

SEAMOLEC's Role

To realise the target enrollment volume for secondary education, the West Java Regional Offic of Education initiated a pilot programme of distance learning assisted by SEAMEO SEAMOLEC. It aims to encourage 16–21-year-old residents to attend high school and increase participation rates in senior and vocational high schools by providing distance learning opportunities to students that have limited access to regular secondary education.

Based on its providers, there are two types of distance learning implementations in West Java. These include senior high and vocational schools with learning centres. The main diffe ence is that vocational schools work with industries as learning centres so they can attract young workers to pursue secondary education without leaving their current jobs. The concept of distance learning for secondary education applied in West Java is shown in Figure 28.

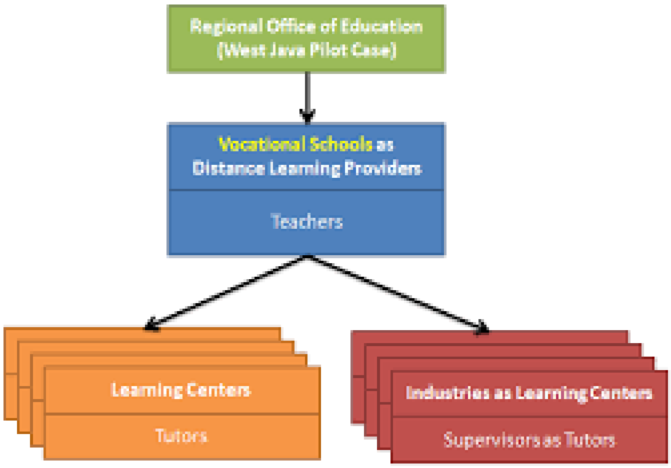

Figure 28: Concept of the West Java open distance learning (ODL) programme

The objectives of this programme are to improve access to and the quality and relevance of secondary education to achieve universal access in Indonesia and improve access to secondary education for junior high school graduates who cannot continue their education due to economic, geographical, time, social, and cultural constraints.

This programme allows learners to study using an independent learning system in cooperation with businesses and industries. It combines distance learning using an Internet-connected network, face-to-face learning, and practice with facilitators from businesses or industries. On a wider scope, this programme is expected to reduce unskilled labour and improve their working skills and capabilities while providing the widest possible learning opportunities to those who cannot attend regular high school.

General Design of Distance Learning in the Secondary Education Programme

This project can be implemented on a national scale, as it involves many stakeholders from diffe ent institutions. SEAMEO SEAMOLEC is deeply involved in developing the general design of this programme, including creating guidelines, making curriculum adjustments, programme development, instructional materials development, and teacher training.

Distance education is carried out within main schools, assisted by learning centres that serve as substitutes for classrooms. There are two types of learning centres for vocational schools, which target knowledge and skills competency development. Centres that target skills competency involve the business and industrial sectors. Their locations are not limited to formal educational facilities. Education can take place at a market, on agricultural lands, or in community facilities, such village halls or the mayor's offic

Learning is carried out every day and at any time. The learning process is designed to be fl xible in that students can learn from their own places of work at any convenient time. To support the effectiveness of learning, students spend five days each week for independent study using printed or digital modules. On weekends, they attend tutorials in learning centres, assisted by tutors.

The distance learning programme was designed to employ a hybrid or blended mode of learning using ICT and based on ODL. The ICT component makes up 30–79% while the remaining percentage of learning happens face-to-face. By employing the hybrid mode, this programme:

- Allows students to study without leaving work (i.e., addresses economic, geographic, and financial reasons and solves scarcity of students). The programme is designed for in-service workers aged 16–21. The admission process is conducted once a year just like in a regular secondary school. The programme was designed to mix face-to-face and independent study. The face-to-face tutorials can help students learn the learning materials better and serve as an effective way for them to interact with tutors and peers. Meanwhile, independent study is facilitated through a learning management system (LMS) called "Sistem Informasi Pembelajaran Jarak Jauh (SIAJAR)," which can be accessed at http://jass.disdik.jabarprov.go.id. It has a wide range of features to help participants manage courses, evaluate learning, communicate with others, and track student attendance and performance. The LMS aims to make students more familiar with online learning.

- Transfers learning through face-to-face tutorials (i.e., synchronous), online tutorials (i.e., through the LMS; asynchronous), and video conferences (i.e., synchronous). Communication between students and tutors occurs through emails, mobile chats, and other digital means.

- Delivers learning materials in three ways—face-to-face, video-conference-based, and web-based. Face-to-face learning occurs during practice and practicum sessions facilitated by tutors. Web-based courses comprise the primary delivery mode, which are enhanced by the face-to-face and video-conferencing components. Web-based learning occurs during independent study. The video conferences are mainly used for coordination among teachers and tutors and discussions of learning problems that students may encounter during independent study. Video conferences can also be explored as an instructional medium.

- Uses various learning resources. All web-based learning resources are available for students and institutions. While the web-based courses are still under development, non-digital learning materials have already been prepared. The user interface (UI) of the LMS will soon follow. Uniform resource links (URLs) to each course's description and topics have also been provided so students can explore them.

At present, the LMS has more than 7,000 teacher, tutor, and class administrator accounts and more than 17,000 student accounts. The LMS already provides more than 1,700 learning materials in the form of student learning modules. Furthermore, more LMS features are being developed to continue providing better distance learning to students.

SEAMEO SEAMOLEC will continue to provide beneficial services to the region to help SEAMEO member countries find alternative solutions to lack of access to education through the effective use of ODL. In the future, SEAMEO SEAMOLEC will initiate more innovations in an effo t to improve the quality of education in the region to fulfill its motto, "Reaching the Unreachable, Making the World a World of Learning."

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Teacher Education in the Age of the Digital Economy: SEAMEO RIHED's Initiatives to Foster Key Skills for the Teachers of Today and the Future

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Abstract

The advancement and spread of digital technologies bring both opportunities and challenges to education, demonstrating a potential to transform the dynamic learning that takes place between teachers and learners. In this transformation, we are witnessing an emerging trend and need to rethink the set of skills and competencies required of teachers. In particular, non-cognitive skills, commonly referred to as "21st-century skills," are increasingly considered essential for teachers today so they can adapt to diverse learning environments. Drawing lessons from the Asian International Mobility for Students (AIMS) Programme of SEAMEO RIHED, this article examines how mobility experiences not only strengthen student acquisition of academic knowledge but also helps nurture their non-cognitive skills. It aims to highlight the potential role of student mobility in shaping the key qualities for the teaching profession in the age of the digital economy.

Keywords: Teacher education, student mobility, digital economy, AIMS Programme

The Digital Economy

Digital technologies and innovations have had a profound impact on economic and social activities. They continue to transform the ways by which society interacts and resulted in intensified connectivity among people, information, and processes. The digital transformation is accelerating, and its effects are penetrating all sectors, ranging from retail to communication and transportation to healthcare and education, heightening the relevance and significance of digital skills for every individual (OECD, 2016).

In the context of Southeast Asia, while the region presents a promising potential to play an active role in the digital transformation of the global economy, challenges such as the digital divide in terms of access to and affo dability of Internet access both among and within countries in the region continues to widen (International Monetary Fund [IMF], 2018).

Innovation and Education

Education is often perceived as a sector that is resistant to change and innovation. At the same time, it is also a sector that is currently and will be experiencing critical changes posed by the wave of digital transformations and integration of technologies into learning processes.

OECD recently conducted research to investigate the perceived level of innovation by sectors in reference to three types of innovation—products or services (e.g., educational materials); technologies, tools, or instruments (e.g., use of ICT in delivering learning content); and knowledge or methods (e.g., new pedagogies, use of ICT for communication) (OECD, 2016). The results revealed that in comparison to other sectors, education is at or below average in terms of speed of adoption of innovation.

The research also examined the perceived level of innovation in the education sector across diffe ent levels. It found that 80% of education professionals employed in higher education institutions (HEIs) considered their workplaces highly innovative compared to other levels of education (i.e., 65% in the primary level and 63% in the secondary level). It is highlighted that higher education stands out in terms of speed of adopting innovation.

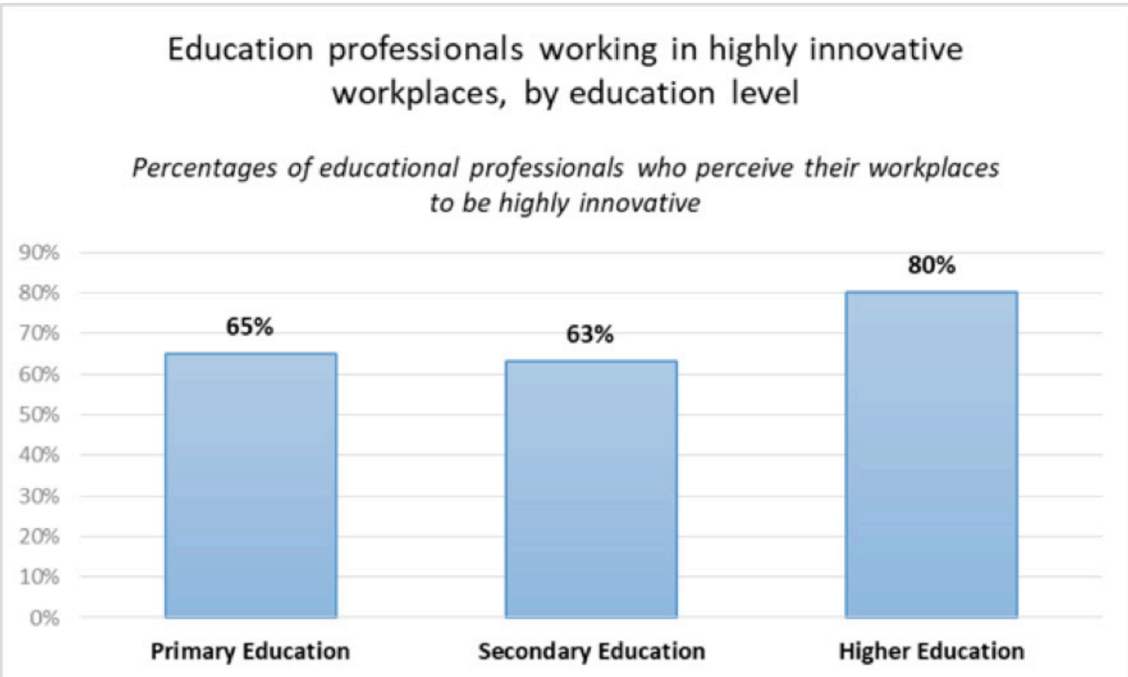

Figure 29: Data drawn from "Innovating Education and Educating for Innovation: The Power of Digital Technologies and Skills" (OECD, 2016)

Digital technologies possess great potential to transform the way teaching and learning is practised in schools and universities and how teachers and learners interact. Technologies can be integrated into teaching and learning settings in various ways. For example, teachers can adopt innovative pedagogic models used in online laboratories for real-time assessment that aims to enhance students' creativity as well as skill in imagining and problem solving. Technologies also bring about extensive international collaboration opportunities by overcoming geographical and time barriers, which may provide students insights into diverse cultures and multicultural communication strategies that are necessary to establish collaborative partnerships in today's interconnected world. In addition, e-learning, open education resources (OERs), and massive open online courses (MOOCs) are other primary examples of how digital technologies can change the way educational contents are delivered to learners while addressing critical issues, such as educational access and equality across education levels.

What Skills Do Teachers Need Today?

The emergence of the digital economy has redefined the skills and competencies required for teachers. Besides technical teaching skills, such as understanding subject matters and pedagogical approaches, classroom management, and organisation, some of the non-cognitive or 21st-century skills that are considered critical for teaching professionals today include:

- **Adaptability:** New ideas and technologies emerge every day, which are changing the way by which students and teachers interact and the process by which learning takes place. Depending on students' learning pace and needs, teachers need to adjust their activities and strategies to achieve better outcomes.

- **Communication:** This skill is necessary for teachers not only in terms of verbal and written forms but also adapting diffe ent communication styles to the needs of students with diverse backgrounds, including age, culture, and personality.

- **Collaboration:** Teachers should consider technology as a means to increase collaborative learning. Collaboration through technology can enhance and diversify students' learning experiences and collaboration, with international partners, can help increase students' awareness of global affairs and understanding of diffe ent cultures.

- **Digital skills:** As technology becomes increasingly integrated into teaching and learning, and plays an essential role in shaping pedagogical practices and strategies, teachers need to be equipped with digital skills and literacy. It also implies the skill to blend effective digital tools in the learning process to create more interactive and student-centred learning environments.

SEAMEO RIHED's Efforts to Nurture Students' 21st-Century Skills through Academic Mobility: The Case of the AIMS Programme

SEAMEO RIHED

As the regional centre specialising in higher education development, SEAMEO RIHED aspires to advance cooperation among and the alignment and development of higher education systems in the region by creating policy platforms, engaging in policy-driven research, and broadening the space for information dissemination. It is committed to taking the lead in advancing SEAMEO Priority Area 6—Harmonising Higher Education and Research. With its key strategic pillars, which are alignment and development, cooperation and synergy, research, and information portal, SEAMEO RIHED continues to engage the region to address new challenges brought forward by harmonising and developing higher education in Southeast Asia.

SEAMEO RIHED's AIMS Programme

Project Summary

Initiated and facilitated by SEAMEO RIHED, the AIMS Programme is a collaborative and multilateral student exchange programme that involves both governments and Higher Education Institutions (HEIs) with the goal of enhancing student mobility in the region and beyond.

In Southeast Asia, past effo ts to promote student mobility concentrated on bilateral agreements between HEIs in the region. Benefits, therefore, have only been limited to HEIs with these agreements. AIMS overcomes this limitation by working with both governments and HEIs to develop a truly regional programme.

By November 2019, AIMS offe ed single-semester exchanges to over 4,950 undergraduate students from nine participating member countries, 72 HEIs, and 10 disciplines. The AIMS participants include member countries, such as Malaysia, Indonesia, Thailand, Vietnam, Brunei Darussalam, the Philippines, Japan, the Republic of Korea, and Singapore.

The objectives of the AIMS Programme are to create a vibrant platform for all citizens of SEAMEO member countries and beyond, promote the mobility of students to cultivate globalised human resources for the region, create and nurture an ASEAN identity in the minds of the learners of the region, contribute to the internationalisation of higher education in the region, and establish the ASEAN community and a regional higher education common space.

Programme Principles and Operational Mechanism

One of the key features that make AIMS diffe ent from other mobility initiatives is the autonomy that it offers to member countries, while providing a structure for collaboration through underlying key principles that guide its implementation. The first principle is self-sufficienc and sustainability where each member country supports its own participation in the programme and new members are encouraged to join based on their own readiness to participate. Balanced mobility and reciprocity is another core principle in that the national authorities responsible for higher education nominate HEIs to participate in disciplines and the number of exchange students is mutually agreed upon and reciprocated in each. Also, the operation of the programme is supplemented by regional mechanisms where regional coordination is undertaken by SEAMEO RIHED to support the implementation and give stakeholders key opportunities to send feedback, address challenges, and propose further developments. The two regional mechanisms that support the programme arethe AIMS Annual Review Meeting and the AIMS Steering Committee Meeting.

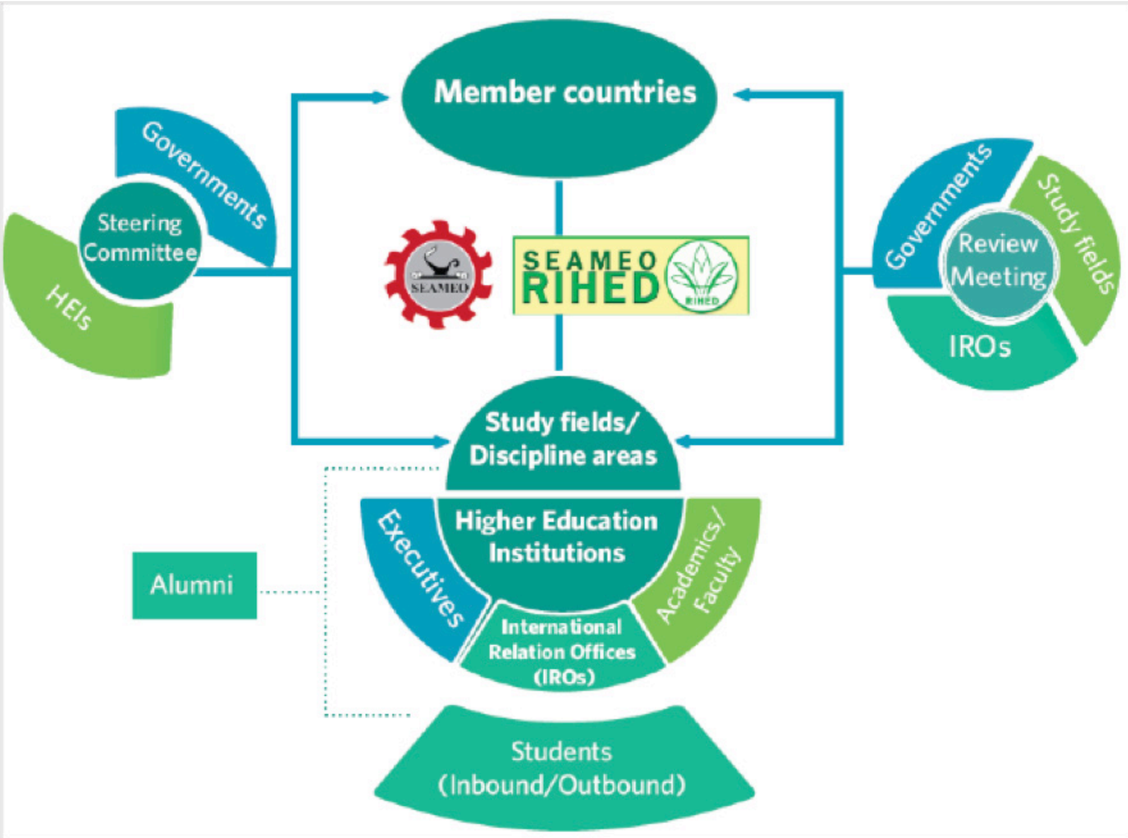

Figure 30: Operational mechanism of the AIMS Programme

What the AIMS Programme Offers Students: Nurturing 21st-Century Skills

The AIMS Programme is a multilateral platform that involves diverse stakeholders in higher education, including students, alumni, governments, and HEIs in the region. It offers unique learning experiences and collaborative opportunities. The programme currently facilitates academic exchange in 10 disciplines, namely:

- Hospitality and tourism

- Economics
- Agriculture
- Engineering
- Language and culture
- Environmental management and science
- International business
- Biodiversity
- Food science and technology
- Marine science

The essence of the academic exchange that the programme provides to the students is not limited to the acquisition of new academic knowledge in host institutions but also includes opportunities to develop and strengthen their non-cognitive skills, which are commonly referred to as "transversal competencies," "soft skills," or "21st-century skills." While cognitive skills involve the ability to understand complex ideas and engage in various forms of reasoning and are associated with reading, writing, and numeric comprehension, non-cognitive skills are defined as "patterns of thought, feelings, and behaviours" comprising personal traits, attitudes, and values (Zho, 2016). Through establishing academic collaboration and close engagement with students, HEIs, and governments in the region, the AIMS Programme has enabled students to gain exposure to diverse cultural contexts and international environments to cultivate the skills necessary to become well-rounded and responsible global citizens and build friendships and community ties both regionally and internationally.

In collaboration with the Ministry of Educaiton (MoE) Korea; the Korean Council for University Education (KCUE); and AIMS member countries, a research project has been conducted to better understand the experiences of students participating in the AIMS Programme along with its outcomes. The survey targeted over 500 people from eight countries who previously participated in the programme. The results highlighted the strong impact of the programme on the participating students in terms of acquiring inter-cultural competencies and the ability to collaborate with people from diverse backgrounds, which are among the core values of the AIMS Programme.

While the programme currently focuses on students as primary targets of mobility, it is important to note that its above-mentioned unique structure also enables faculty and administrative staff from member HEIs to gain exposure to the internationalisation process, for which cross-border collaboration, inter-cultural communication, and problem-solving skills are among the key elements to move forward.

The AIMS Programme does not currently address teacher education directly in its mobility scheme. The 10 disciplines above have been refined and selected through ongoing discussions and mutual agreements between stakeholders, as either common areas of focus for member countries and participating HEIs or strategic priority areas for developing expertise in the region. Nevertheless, discussions have been held to add more disciplines and explore further opportunities for partnership, as the programme aspires to become a platform to promote broader academic mobility, including mobility for teaching and administrative staff of member HEIs

The mobility experience demonstratively provides learners with opportunities to strengthen key skills required for teaching professionals in the digital economy, such as those associated with effective communication, collaboration, and adaptability. In addition, with the transformation brought about by digitalisation and its impact on the way teaching and learning takes place, anyone who has expertise in subject areas has the potential to be an educator. Therefore, the region must foster cross-border collaboration to promote mobility among general students and both pre- and in-service teachers who play a crucial role in shaping global citizens.

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Real-Time Participatory Mapping for a Disaster and Emergency Preparedness System: A Case Study of Teacher Involvement in Centre Sulawesi-Indonesia

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Abstract

The Real-Time Participatory Mapping for Disaster and Emergency Preparedness System (RT-PADEPS) has a significant role to play in disaster management. It is an idea to adopt open web standards to share map services based on participatory geographic information system (P-GIS) and spatial notifications for emergency conditions, such as disasters, accidents, and emergencies. The objective of this research is to develop a collaborative web GIS based on real-time geo-tagging of emergency occurrences. This model was generated due to a case study in the aftermath of earthquake and tsunami in Palu, Centre Sulawesi, Indonesia. This system was not only applied to gauge the heartbreaking occurrence but also estimate or analyse areas affec ed by the disasters, along with damaged buildings and facilities. Moreover, it shows currently available access and fastest routes to impacted areas. Finally, the system could connect users to authorised agencies to inform them or request immediate action regarding emergencies. Through the integration of spatial information into the web GIS and mobile platforms, it can quickly and accurately collect and share information as soon as possible.

Keywords: Disaster preparedness, emergency, GIS, RT-PADEPS, spatial

Introduction

Indonesia is located within the ring of fi e and is extremely vulnerable to natural disasters. This tropical country has an abundance of natural resources, but it faces complex geographical conditions. In addition, Indonesia also has human resources distributed in villages and urban areas. Most of the areas in the country are prone to natural disasters, such as earthquakes, tsunamis, and volcanic eruptions, and liquefaction (Kusumastuti, et al., 2014). The government recorded several natural disasters in 2000–2018. A couple of tragedies that include earthquakes, tsunamis, and liquefaction occurred in Centre Sulawesi on 28 September 2018. These impacted the people who live in vulnerable areas such as coastal zones.

A disaster and consequent emergencies can happen anywhere and at any time. As such, quick and appropriate actions to provide technical assistance and take care of victims are necessary. A reliable and easy-to-operate system has thus been adopted and optimised using available resources and facilities in certain locations and regions, such as RT-PADEPS. Human resources are also needed to collect and provide valid sources of information. Integration into spatial technology tools can be optimised by using a P-GIS (Forrester and Cinderby, 2015).

RT-PADEPS adopts an open web standard for sharing map services using P-GIS and spatial notifications for emergencies. It can be operated by the government, schools, volunteers, or private institutions to support authorised agencies or decision makers, as they take action and deal with emergencies and manage post-disaster processes.

This article describes the development of a web GIS based on the real-time geo-tagging of emergencies.

Literature Review

Collaborative Mapping of the School Community

Disasters can result in the loss of lives, injuries, and property destruction in a community. Risks can be determined, however, as a function of hazards, exposure, vulnerabilities, and capacities (United Nations [UN]/International Strategy for Disaster Reduction [ISDR], 2017). Identifying and quantifying risks spatially can assess hazard intensity and vulnerability magnitude (Peggion, et al., 2008). These can pinpoint sources of spatial collaborative information using GIS technology.

A GIS is the best tool for understanding and organising data gathering, management, and analysis. In fact, online platforms, such as web GISs, can now analyse and visualise spatial data. They can also be used to gain deeper insights to spot patterns and relationships (Esri, 2018). Web GISs can help users make smart and accurate decisions faster to manage natural disasters.

GIS technology can identify and quantify risks. It can be enhanced by a participatory mapping collaboration with school communities that wish to help affec ed areas. Senior vocational schools in Indonesia, for example, can serve as hubs of information. They can also be tapped to improve understanding and knowledge about mitigation, preparedness, and emergency response.

Participatory Mapping

Participatory mapping is a bottom-up approach that allows communities to create maps for certain user types. In contrast with the traditional top-down approach, it relies on those with the power and resources to create maps that will benefit the masses either directly or indirectly (Warner, 2015). With some modifications and newer tools, the participatory mapping approach can be made interactive to produce more accurate data faster. Contributors can send and share data to support decision makers in carrying out actions or crafting policies.

Cloud Computing

Cloud computing can distribute data processing to become more scalable in terms of resource and capacity to serve multiple users at the same time. It has three basic concepts—infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS).

IaaS involves building a computer infrastructure and virtualisation. All services are hosted on the infrastructure. PaaS, meanwhile, involves an integrated platform for developing, deploying, testing, and supporting web-based applications. Finally, SaaS follows the business model for software licensing, where development and support for the program is taken care of by the vendor. Users can use the software through the Internet. In this research, the SaaS model was implemented for the geo-processing service. Connecting to the information base from affec ed locations and sharing data increased the ability of the system and the community.

Methodology

Project Location

Two locations were chosen for the trial of RT-PADEPS—Palu City and Sigi in Centre Sulawesi.

Figure 31: Research locations

Data Requirements

Several types of spatial data were used in this project. Imagery, base maps, and thematic data were obtained from government portals. The validation data was acquired through a field survey. All data requirements are shown in Table 11.

Number	Data Type	Resolution and Scale	Format	Source
Imagery Data				
1	Very high resolution (VHR)	0.3–0.5 metre	Raster	Government Private
2	High resolution (HR)	10 metres	Raster	Government Private
3	DEM	8 metres or 30 metres	Raster	Government Private
4	Aerial data (UAV)	10 centimetres	Raster	
Geospatial Basic Information				
1	Administrative boundary	1:250,000	Vector	Government
2	Road network	1:50,000	Vector	Government
3	River network	1:25,000	Vector	Government

Number	Data Type	Resolution and Scale	Format	Source
4	Land use and cover	1:25,000	Vector	Government
5	Countour	1:25,000	Vector	Government
Geospatial Thematic Information				
1	Soil	1:25,000	Vector	Government
2	Climate	1:50,000	Vector	Government
3	Slope	1:25,000	Vector	Government
4	Vulnerability	1:250,000	Vector	Government
5	Hazard	1:250,000	Vector	Government
6	Risk	1:250,000	Vector	Government
7	Resilience	1:50,000–1:250,000	Vector	Government
8	Regional spatial plan	1:5,000–1:50,000	Vector	Government
9	Population	1:250,000	Vector Tabular	Government
10	Culyural, social, and economic		Tabular	Government

Table 11: Data requirements

The project focused on developing a database and various spatial data handling standards, RT-PADEPS, and community training resources. The data was processed using several preprocessing and spatial analysis approaches. RT-PADEPS's web GIS consists of three main components (see Figure 32).

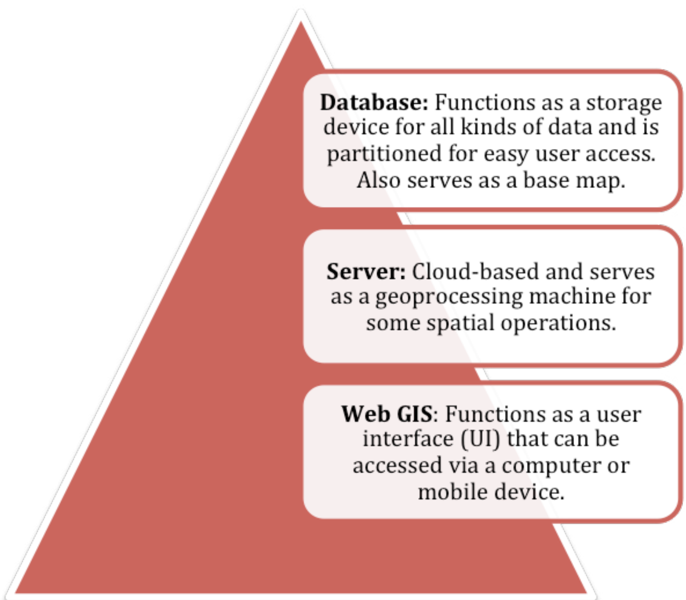

Figure 32: Main components of RT-PADEP

The development of RT-PADEPS was divided into five major steps—assessment, database design, system design, testing and evaluation, and training and implementation (see Figure 33).

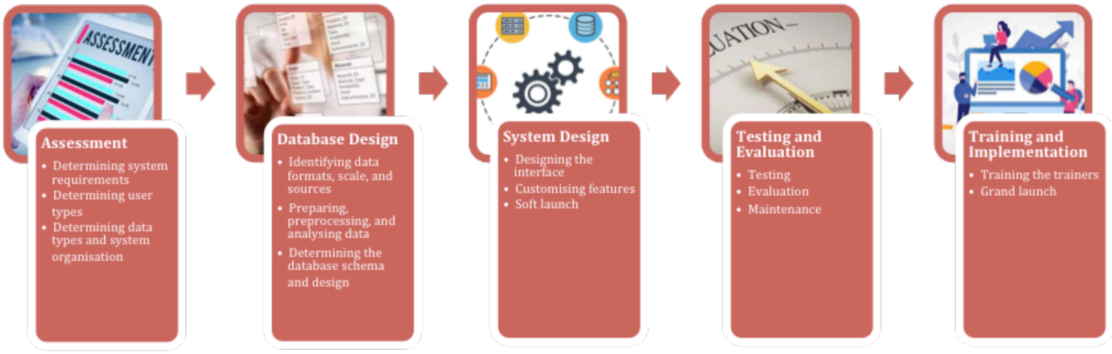

Figure 33: System development process

Architecture

RT-PADEPS optimises the capability of Indonesia's geo-processing services, which power applications like ArcGIS. A geo-processing service does one or more tasks on a server (Esri, 2018). Users are divided into two categories—administrator with full management capability and user with limited capability. Figure 34 shows the detailed architecture of a typical geo-processing service.

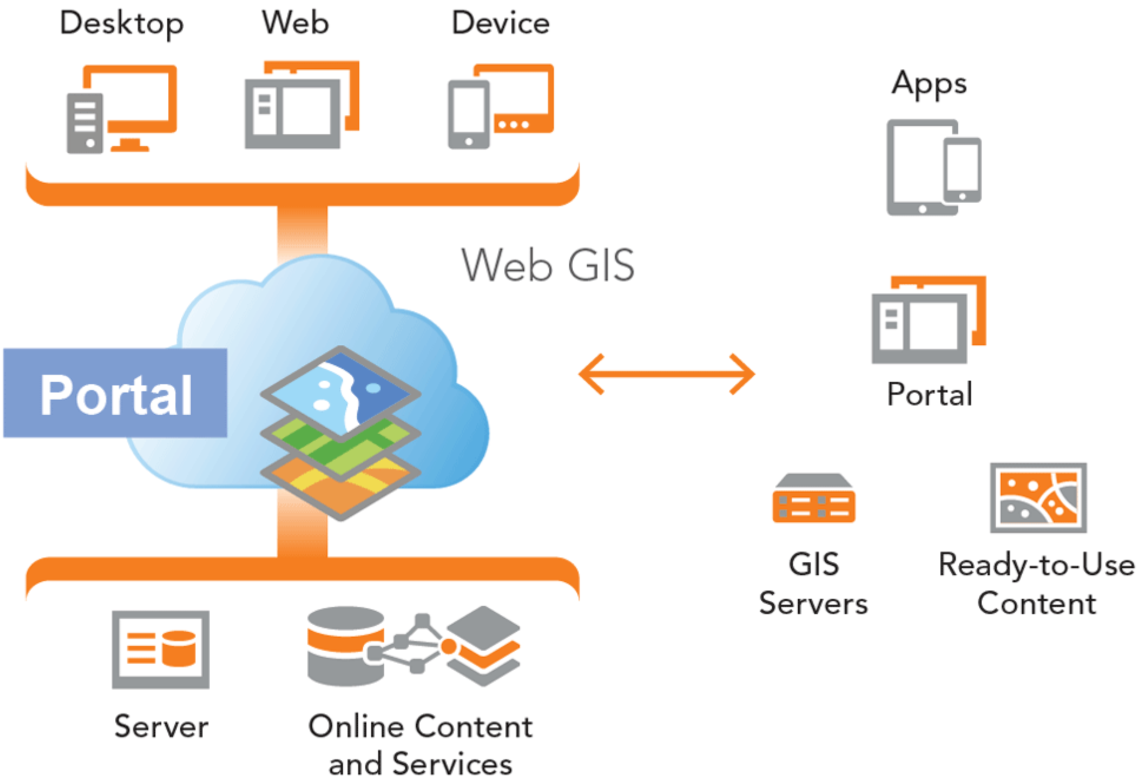

Figure 34: Geo-processing service architecture (https://www.esri.com/about/newsroom/arcuser/portal-for-arcgis-101/)

Expected Results

The expected result from this project was a web GIS application that can be implemented for participatory mapping for disaster and emergency management. It should be easily accessible via computers and mobile devices and support emergency actions from authorised agencies. The design of RT-PADEPS is shown in Figure 35.

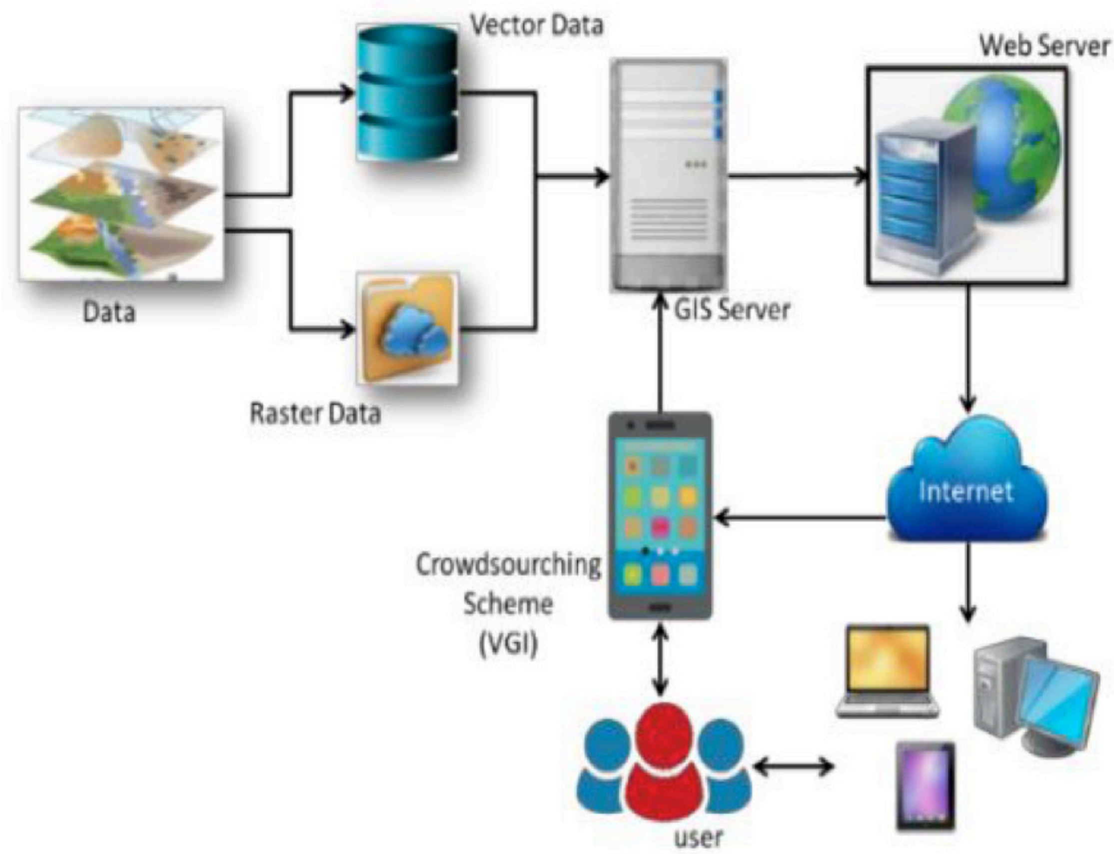

Figure 35: RT-PADEPS expected output

Results and Findings

FGD and Rapid Survey

SEAMEO BIOTROP initiated several activities in preparation for the development of RT-PADEPS. These include focus group discussions (FGDs) to assess the impact of disasters on affec ed areas. One such FGD was conducted in State Vocational High School 1 of Sigi (SMKN 1 Sigi). This event was attended by teachers and explored and assessed available data. Meanwhile, spatial data collection and a rapid survey were conducted using drones in several impacted areas.

The FGDs revealed that all of the buildings in SMKN 1 Sigi were damaged by an earthquake on 28 September 2018. The participants proposed three courses of action—reconstruct the school buildings, rehabilitate the school garden, and improve the school's disaster mitigation and risk reduction and management capability. The participants also mentioned that they did not have a management system that can assess and calculate losses and damage to facilities and buildings due to lack of data before the disaster struck.

System Prototype

Based on the results of the assessment, team researchers developed RT-PADEPS using Centre Sulawesi as a case study. The researchers built a prototype of RT-PADEPS. The main interface had several features that showed layer data, maps, and other information. The layer data supported all data formats, such as vector, raster, and numeric data. The main map overlaid data from several sources. The graphical system showed charts of available data. And a base map of all data sources (i.e., topographical data, open street map [OSM] data, imagery, and administration data) is also available (see Figure 36).

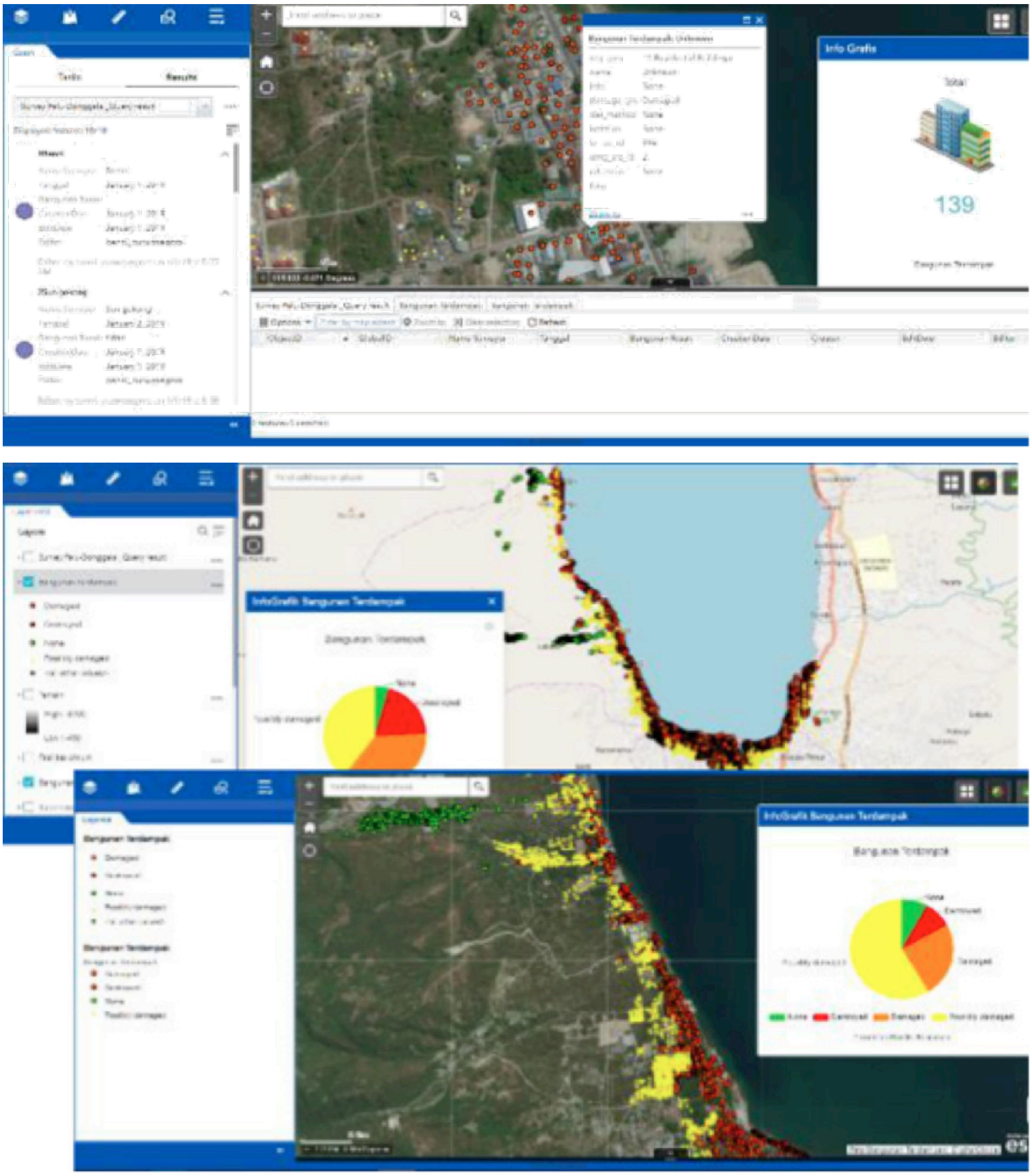

Figure 36: RT-PADEPS prototype real-time data interface

RT-PADEPS shows affec ed areas, including buildings and facilities. The information was collected from various contributors that include school communities in the area.

Figure 37: Real-time participatory data gathering

RT-PADEPS also allowed users to compare before and after pictures of affec ed areas using time series imagery data (see Figure 38).

Figure 38: Before and after comparison through RT-PADEPS

Future Model Development

SEAMEO BIOTROP Spatial Development Planning

SEAMEO BIOTROP was established three years after the ***SEAMEO Charter*** was signed on 26 February 1968. It is one of SEAMEO's 26 regional unit and aims to "provide scientific knowledge to and build the capacities of institutions and communities in conserving and managing tropical biology sustainably for the well-being of communities and the environment." That is why developing spatial technology is one of its most important concerns.

SEAMEO BIOTROP has a comprehensive spatial laboratory called the “Remote Sensing and Ecology Lab.” With several mapping equipment support, software, and spatial databases, it has become a leading centre in developing spatial technology and research and welcomes the cooperation and collaboration of other organisations for projects and research initiatives.

Model Development Road Map

The prototype still requires further development and refinement in terms of infrastructure, capabilities, and facilities so it can operate better. It also requires funding support from other institutions. The prototype will be used for a training course on disaster mitigation and management for schools starting 2019. A detailed road map for RT-PADEPS training use is shown in Figure 39.

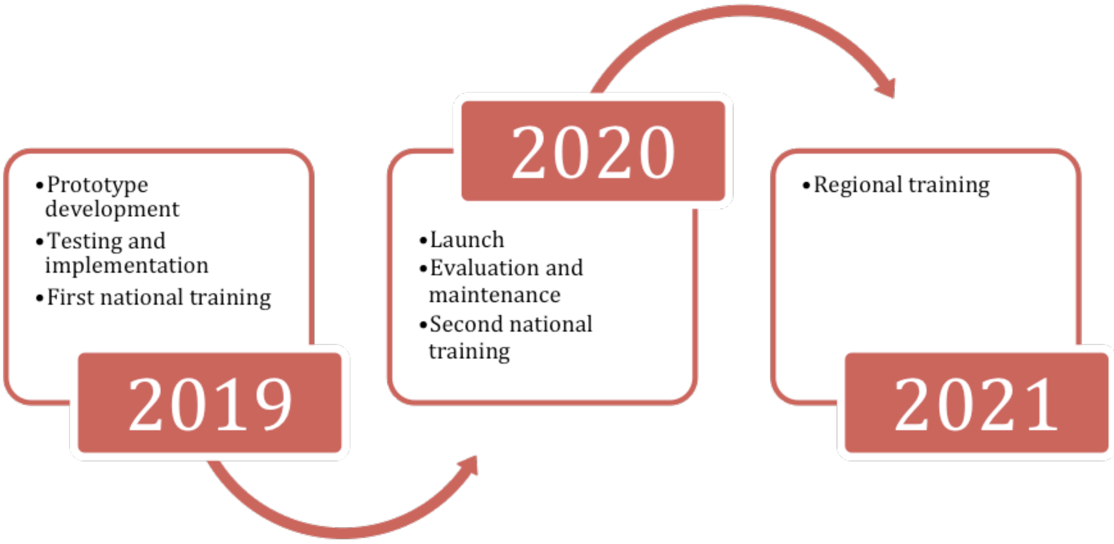

Figure 39: RT-PADEPS training road map

Module Development

According to the RT-PADEPS prototype, two training modules for vocational school teachers are required. The first will be used for fundamental to intermediate content. It will tackle eight topics—introduction to emergency and disaster management; introduction to GIS and remote sensing technology; introduction to GIS software and tools (licensed and open source); utilising GIS software and tools (licensed and open source); producing and editing spatial data; introduction to spatial and image analysis for participatory disaster mapping and emergency preparedness; laying out, printing, and publishing maps; and field trips (su vey and practice).

The second will target advanced learners. It will also have eight topics—data analysis for emergency and disaster management; introduction to web GIS; spatial data querying; spatial model implementation for participatory disaster mapping and emergency preparedness; using participatory disaster mapping and emergency preparedness systems and geo-processing services; spatial and image analysis for participatory disaster mapping and emergency preparedness; laying out, printing, and publishing maps; and field trips (su vey and practice).

Conclusion

RT-PADEPS is still in need of improvements before it can be widely implemented in vocational senior high schools. It will require more case studies and data inputs to grow its database so its web GIS functionality can truly become a good model for disaster mitigation and risk reduction management.

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STEM Village: Promoting and Spreading Awareness about STEM to Families and the Society

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Abstract

In the 21st century, STEM competencies are sought-after fields that are significant in developing a country. The advancement of a national workforce is often judged by the educational achievement in STEM competencies by students and, consequently, by the quality of its STEM workforce. However, the effo t to support and sustain this endeavor rarely goes beyond the school classrooms. Families, as the nucleus of civilisation and basic social unit of society, have a strong potential as a medium for promoting STEM. This article aims to discuss STEM Village, a project by SEAMEO QITEP in Mathematics, in an attempt to create a series of out-of-school activities designed for children and families to promote and spread awareness of STEM through activities that are engaging, low-cost, context-suitable, and relevant to daily life.

Keywords: STEM, STEM Village, family, extra-curricular

Introduction

For the last two decades, STEM has become a popular innovative strategy to improve student achievement. The acronym, "STEM," was coined by the National Science Foundation in the 1990s (Sanders, 2008). In the U.S., STEM education has become the priority of the government and experts have predicted that jobs in STEM will increase by about 17% in 2018 (LaForce, et al., 2016). STEM education is not only concerned with integrating the fields of science, technology, engineering, and mathematics. It is an interdisciplinary learning where real-world problem- and project-based learning is meaningfully implemented (English, 2016 and Force, 2014). STEM education has been developed in several countries around the world and research has also been conducted regarding it.

STEM education has been a major buzzword for quite some time now in Indonesian education. Even though there are no regulations regarding the integration of STEM officiall into the national curriculum, various STEM-related educational agenda have emerged from diverse educational institutions (i.e., seminars, workshops, etc.). In mid-2018, the Ministry of Education and Culture (MoEC of Indonesia) held a nationwide training programme for science and mathematics middle school teachers that aimed to introduce STEM education and familiarise them with how to apply it in teaching.

However, the effo t so far has been strictly confined to school settings. STEM lessons that have been introduced to teachers so far are designed for classroom application and are strictly concerned with staying within curricular guidelines. The teachers' concerns mostly revolve around assessment, subject content, and how STEM education would help students excel in the national exam. As a consequence, STEM education became viewed as an approach that strictly belonged to the school environment.

This article will discuss the potential of an out-of-school STEM education programme and the design for such a programme in an Indonesian context. On that note, it is not meant to be a detailed report of a carefully designed research project. Rather, it aims to propose an idea and deliver an example that the readers might find worth trying in their respective contexts. Perspectives from the participants of the programme are also provided as supporting points of view.

OST STEM Activities

An educational programme focused on STEM for out-of-school-time (OST) is not an entirely new idea. In the U.S., the birthplace of STEM as an educational approach, there is growing interest and investment in OST STEM programmes (Bevan, et al., 2010). Federal agencies and researchers advocate the use of OST to support and supplement the knowledge that students learn in school. Aside from supporting formal learning, OST STEM activities are also beneficial to female and racial minority students, which is a major agenda item for the U.S. educational system. Because OST activities are not strictly linked to the school curriculum, these programmes are easily customisable to fit students with ce tain needs, such as female or racial minority students.

By default, OST STEM activities are learning activities that occur outside formal school settings and are often described as personal, contextualised, and time-consuming (Dierking, et al., 2003). We also need to make a distinction between structured and unstructured OST STEM activities (Dabney, et al., 2012). Structured activities include museum visits, after-school clubs, mathematics competitions, and the like, while unstructured activities are those that happen solely because of the students' personal interests (e.g., tinkering with objects, doing experiments on their own, or researching things online). The OST STEM activities described in this article will be limited to structured ones.

Even so, structured OST STEM activities are still versatile and open to various options, such as involving an established institution outside school like a museum or national park or offe ed by the school as an extra-curricular activity. The activities can be conducted in indoor or outdoor settings. The programme can be designed to require continuous attendance over certain periods of time, or fl xible participation, where the students are free to decide according to their availability and interest. When it comes to knowledge, it can focus on certain content domains or lean more towards the general application of STEM in everyday life.

Despite the variation, there are several diffe ences between OST STEM activities and STEM activities within school settings (Bevan, et al., 2010). First, OST STEM activities tend to be less verbal and abstract. They are usually more tactile and built on sensory experiences with real-life resources (i.e., places, phenomena, data, and tools) that are often difficul to integrate into actual classrooms. Second, OST STEM activities provide more ground for group or collaborative investigation, rather than individual learning activities. Students who are not doing well with collaborative learning in a formal school setting can learn to work with others in an out-of-school setting. Third, because OST STEM activities are less confined within mandated curricular guidelines, the students can learn in a more fl xible way that puts their knowledge development first, instead of merely focusing on exams. Time is usually the biggest obstacle for teachers in trying out experimental lessons, therefore, OST activities allow teachers and students to pursue ideas they find interesting at their own pace. Last but not least, OST activities are low-stakes (i.e., non-evaluative). They put less pressure on students to be correct or do well. This is especially important for students who have been discouraged by a conventional STEM environment (e.g., within school, discouraged either by being identified as incompetent, by judged that STEM subjects are not "suitable" for them). This usually happens to girls, minority students, or socioeconomically disadvantaged students.

Several reasons make OST STEM activities worth considering. As the initial movement for STEM was started by the need for a more competitive workforce in STEM fields, it is no wonder that programmes that focus on making students more interested in a STEM career are widely favoured. The link between OST STEM activities and career choices are of interest because they emphasise curiosity and the enjoyment of learning of certain topics, instead of emphasising achievement and test scores (Krapp, Hidi, and Renninger, 1992). OST STEM activities ignite the students' interest in STEM fields and develop and expand their understanding, which leads to them to become more aware of the role STEM careers in the society (Bevan, et al., 2010). Research by Dabney, et al. (2012) showed that participation in OST STEM activities encourages students to pursue university majors in mathematics and science, and eventually select a career in related areas. The less strict confinement of the school curriculum, the lack of formal assessment, and the greater emphasis on daily life applications all contribute to the importance of such programmes.

The National Research Council (2015) identified three criteria for successful OST STEM programmes—being engaging, being responsive, and making connections. These criteria are broken down into more detailed criteria, as shown in Figure 40.

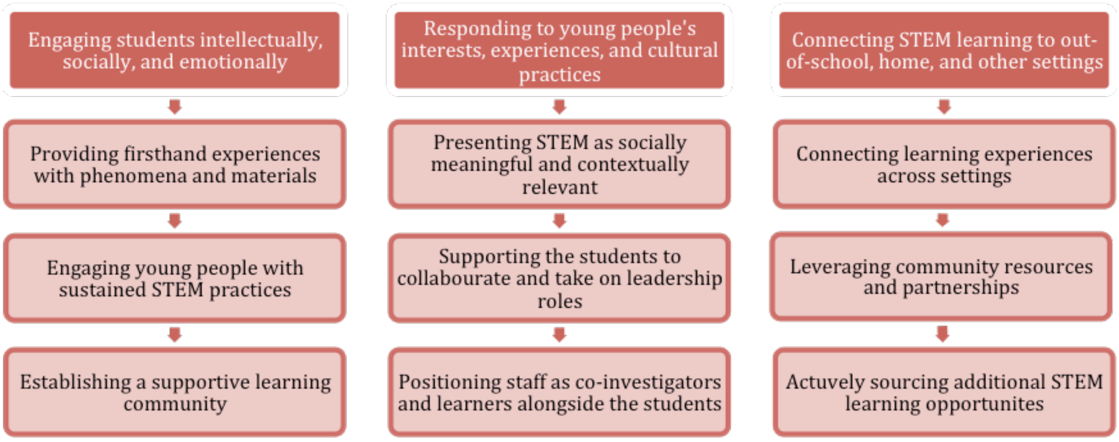

Figure 40: Criteria for successful OST STEM programmes

Family Involvement in OST STEM Activities

One factor argued by researchers as a main contributor to student interest in STEM subjects comprise the novel and engaging problems that are relevant to real-life situations (Dabney, et al., 2012). Another factor found pivotal in the development of students' attitudes towards STEM subjects is parental involvement (George and Kaplan, 1997). The STEM learning ecosystem model created by L.S. Liben (National Research Council, 2015) also identified that homes, neighbourhoods, and out-of-school experiences have an impact on student learning development in school (see Figure 41).

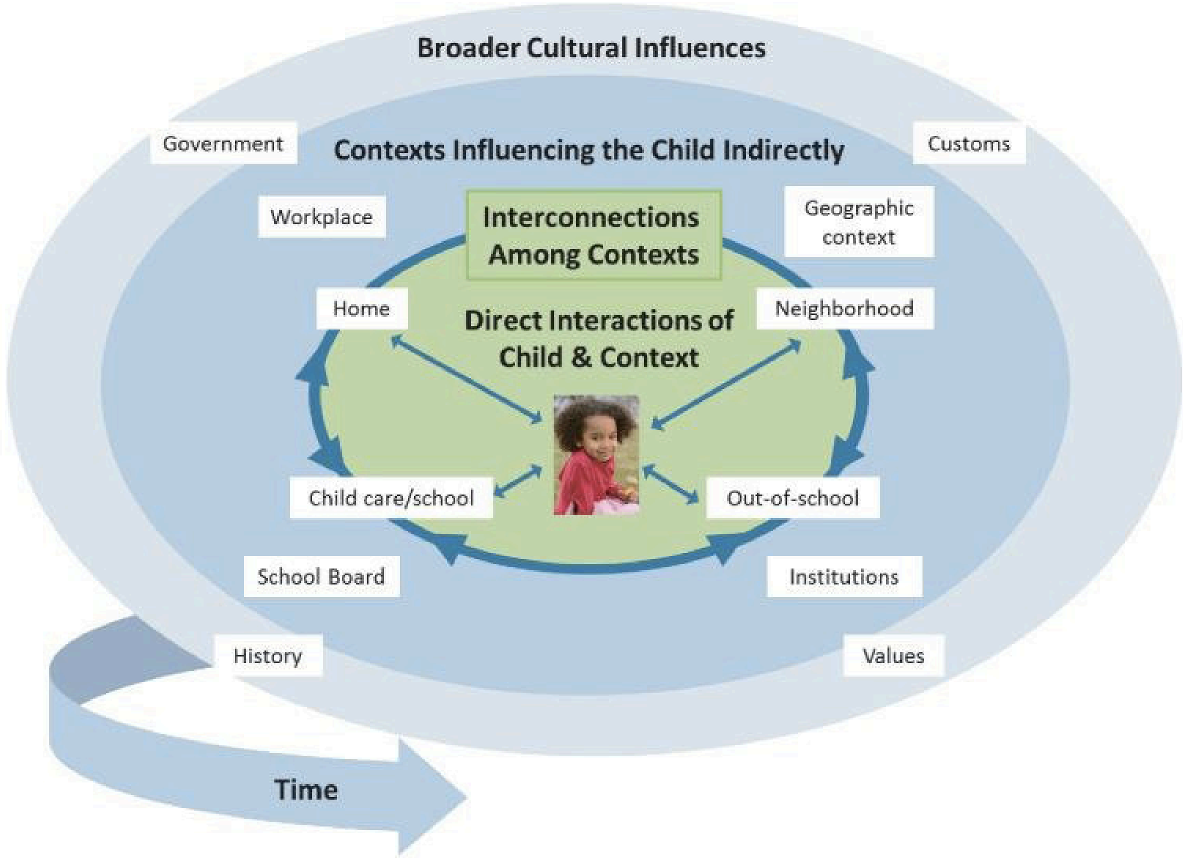

Figure 41: STEM learning ecosystem model (National Research Council, 2015)

Based on the results of these studies, community- and home-based OST STEM activities are inevitably a promising path for future researchers in this area.

Kampung STEM or STEM Village

We decided to design OST STEM learning activities involving families as part of the programme of SEAMEO QITEP in Mathematics, which we called "Kampung STEM" (in English, "STEM Village"). Children and mothers from communities around our offic participate voluntarily in the STEM programme held once a week with diffe ent topics and activities. The project is still in the initial stages but is ongoing, with more than 12 mothers and around 10 kids regularly attending every session. , as well as some irregular attendees.

Although it is still in the initial phase, this programme attempted to apply the principles identified as contributors to successful OST STEM activities. First, parental involvement is integral to the programme. And so, even though only mothers are participating so far, their activities are separated from the children's. Second, the contexts used in every activity are socioeconomically and culturally relevant. This does not mean that the topics only stay within the zones that are familiar to the students. We also attempt to introduce global issues to them while making sure that the learning process is attainable from their starting point (i.e., either the local context or the students' content knowledge). The materials are designed to be low in cost and easy to acquire. Third, the activities provide practical, tactile, and hands-on experiences for the participants and offer a chance to work collaboratively with others. Last but not least, the programme is conducted in partnership with the local community. Especially for the mothers, we made sure to incorporate the element of entrepreneurship to the activities. Aside from making it more engaging, it also opens possibilities for supporting the family's economic needs. Above all, the overarching aim of the whole programme was to introduce and bring awareness of STEM in hopes of developing a positive attitude towards and interest in STEM subjects.

The following are some examples of the activities conducted in this programme.

Batik Ikat Celup (Shibori/Tie-Dye)

Textile manufacturing is a huge part of Indonesian culture, which has resulted in a variety of traditional textile colouring methods. These traditional methods commonly involve a resist technique or diffe ent ways to prevent colours from reaching fabrics, thus creating patterns. One of the most renowned is *batik*, which uses a resist method that requires drawing patterns on the fabric with wax, hence preventing colour from seeping through the entire fabric. Batik is one of the most prized cultural heritages of Indonesia and is an integral part of the society, from informal daily life to formal and luxurious events.

However, there are other colouring methods that are just as interesting but less explored, such as batik ikat celup, also commonly known as "shibori" or "tie-dye." The resist methods involved require tying the fabric, thus creating resistance that prevents colour getting to parts of the fabric. Diffe ent tying methods will result in diffe ent patterns and colour combinations.

Figure 42: A product of batik celup ikat

Batik ikat celup is a potential STEM activity because of the science and mathematics involved in making the patterns and mixing the colours, which can be either artificial or natural. From the technological perspective, the batik ikat celup method is a technology invented by humans in pursuit of easier cloth-dying methods. Meanwhile, the engineering aspects come from the form of creating diffe ent patterns and colour combinations.

Aside from promoting STEM, batik ikat celup is also an excellent entrepreneurial activity. The batik ikat celup fabrics and clothes produced by the mothers have been shown in several local exhibits and received interest from potential customers.

Ecoprint

Aside from tie-dye, another colouring technique that is also less explored is ecoprint. This colouring method strictly uses natural colour pigments found in plant body parts like leaves and flowers. The leaves and flowers are laid down between two sheets of white fabric and hit repeatedly to break and release colour pigments. The fabrics are then rolled into a small fold, tied with rope, and steamed or ironed. This process will produce the stamps of leaves or flowers on the fabric, thus creating interesting natural patterns.

Figure 43: Ecoprint activities of mothers

The colour pigmentation of leaves and flowers will serve as an excellent ground to learn about plants. From the perspective of technology, ecoprint in itself is a technology invented by humans as an easy cloth-dying method, while the engineering aspect comes from the creation of diffe ent patterns and colour combinations.

Just like shibori, ecoprint is also an excellent entrepreneurial activity. The ecoprint fabrics and clothes produced by the mothers have been presented in several local exhibits and been received positively by potential customers.

Wiggle Bot

The wiggle bot activity is for students. This activity involves making simple robots from objects found in the environment. The product is a simple robot with pens tied to a body made from cups and spinning arms moved by dynamo or motor.

Figure 44: An example of a wiggle bot made by the children

The wiggle bot activity aims to introduce the simple principle of robotics—no matter how complicated, a robot needs both a power source and a motor to move. Today, robotic technology is used in various fields with diffe ent levels of complication. We attempt to introduce the students to this technology by starting with something simple that can be easily acquired from everyday life objects.

What the Participants Think of Kampung STEM

We interviewed some participants of Kampung STEM to provide their perspectives regarding the programme. The interviewees were appointed by the project manager and there is no parental relationship between the mothers and the children interviewed. During the interview, the researcher focused on gaining the participants' perspectives on which Kampung STEM activity they benefi ed most from and why, the scientific awareness they gained from the programme, and their future expectations.

Three children took part in the interviews—Putra, Bayu, and Indra. Note that these names are pseudonyms. Putra, a third grader, and Indra, a sixth grader, mentioned the air-pressure rocket activity as their favourite. Bayu, a sixth grader, was a big fan of the wiggle bot activity. The easy-to-find and cheap materials, often from scraps, were their main points of interest. They enjoyed obtaining knowledge from activities that they usually do not do in school. They also liked getting a chance to play with their friends while still learning and being productive. Even though their career choices are not STEM-related, they cited the ability to create and build things as a benefit of Kampung STEM, as depicted by following excerpt from the interviews:

Interviewer: *What benefit did you gain from Kampung STEM?*
Putra: *So that when I grow up, I can make and build stuff…*
Bayu: *… that are useful for the society.*

The children found the activities exciting and could recount their science and mathematics aspects. However, they still find it difficul to explain the role of science and mathematics in the whole experience of rocket-flying or making wiggle bots move. This indicates that the activities need to emphasise the engineering aspect. The STEM Village instructors can let the children tinker around to solve problems and discover solutions instead of giving them specific instructions o build things.

As for the mothers, three participants were interviewed as well—Mrs. Puspa, Mrs. Jemma, and Mrs. Julia. All of the names are pseudonyms, too. Mrs. Puspa (47 years old) and Mrs. Julia (43 years old) are both stay-at-home moms while Mrs. Jemma (53 years old) is a market vendor. They all agreed on textile-related activities as their favourite (e.g., ecoprint and tie-dye or shibori). They cited many reasons such as the ability to channel their artistic expression and its entrepreneurship potential.

Further discussions on the benefits of Kampung STEM revealed how STEM activities can empower women. Most if not all of them were stay-at-home moms who mostly do household chores. Kampung STEM activities provided them a chance to socialise while still being productive. In case they want to do their projects at home, they can manage to in-between doing housework. The entrepreneurship aspect was their main and strongest interest, as the products from the textile activities turned out to be lucrative for them. Mrs. Puspa, for example, said the following:

> “*I think what I love the most about Kampung STEM is that it has real, actual results. We used to sit around with nothing to do. Now, we can do ecoprint instead. So, our free time is not wasted anymore. We can go out and hang out while still being productive… I want Kampung STEM to be an object of tourism, the identity of our village. People can visit and we can generate more income from it.*”

Future expectations, aside from making Kampung STEM a tourist destination, include planned and organised marketing. So far, marketing is done sporadically through occasional exhibits and mouth-to-mouth promotion, which leaves ample room for improvement.

STEM Village so far has shown potential to become a platform for families to not only explore STEM subjects and their relevance in solving problems in real life but also encourage STEM career choices for children and provide entrepreneurial activities for mothers. This project brings the potential to promote STEM not only in a school setting but also in other contexts that are close to the children's life, such as at home, within families, and in neighbourhoods.

Conclusion

However, as the STEM Village project is still in the initial stages, there are several concerns that we need to address. The first one has to do with the topics. Even though the OST STEM programme does not aim to adhere to certain school curricula, we still need to select and establish a sequence of topics that can be used as guide in the STEM Village. The second concern is evaluation. We need to establish a way to assess and evaluate the effectiveness of the programme. Last but not least is scalability. Our hope is for the STEM Village project to reach a larger audience. As such, there is a need for a reliable method that can be scaled according to the diffe ent settings or number of participants.

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Academic Mobility Strategies and Challenges: The T.I.P. Experience

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Abstract

This article presents the strategies and actions taken by T.I.P to meet challenges such as academic mobility, specificall , its participation in the SEAMEO SEA-Teacher Programme.

Keywords: Student mobility, SEA-Teacher Programme, SEAMEO

Introduction

T.I.P. envisions to become a leading professional technological institution through fostering outcome-based education, a culture of innovation and continuous improvement, and an institution whose graduates contribute to the welfare of the society.

In support of the educational objective to produce graduates who are globally competitive, T.I.P. strategically partnered with local and international colleges and universities and kept close alliances with professional organisations, government agencies, and industries. Through these linkage partnerships, various areas of cooperation were realised to enhance the institution's capability to deliver its functions of instruction, research, production, and extension. Major areas of partnership include cooperative education, capacity building, collaborative research, and industry-commissioned projects, among others.

The varied organisations that T.I.P. has forged linkages with have contributed to improving its curricula and educational processes to become more relevant to the needs of the society. Thus, they have contributed to the attainment of the institutional-intended outcomes for T.I.P. graduates.

T.I.P. continues to expand its cooperation with international partners with the end in view of strengthening faculty competence, enhancing academic learning, and realising excellent performance through academic mobility.

Government Policy on Academic Mobility

The Philippine government programmes on academic mobility are expressed through ***Commission on Higher Education (CHED) Memorandum Order (CMO) No. 55 s. 2016***, also known as the "Policy Framework and Strategies on the Internationalisation of Philippine Higher Education [1]." The CMO aims to:

- Articulate the Philippine higher education internationalisation policy to provide a national perspective and context for various initiatives related to the subject
- Guide the Philippine higher education sector's internationalisation effo ts, bearing in mind national interests, security, and identity while also contributing to the improvement of the country's competitiveness
- Define the st ategies that underpin the various modes of internationalisation
- Set the principles to guide Philippine HEIs in pursuing internationalisation programmes
- Encourage Philippine HEIs to adopt a programmatic approach to internationalisation
- Serve as basis for improving programmes, policies, and standards on internationalisation activities, cognisant of the need for appropriate government regulation for a cohesive internationalisation thrust and in affirmation of Philippine eĀ ts to uphold its global higher education reputation

TIP Programmes on Academic Mobility

In support of the government's thrust on academic mobility, T.I.P. implemented both home-based and cross-border internationalisation activities. Academic partnerships with local and foreign universities were established to share resources, exchange students and faculty, and other collaborative undertakings.

Home-Based Internationalisation

Lack of financial capacity is a major challenge for outbound faculty members and students of T.I.P.. A majority of T.I.P. students belong to lower economic bracket families and the availability of government funding is very limited. Thus, only a few can affo d to finance an academic mobility activit .

With this constraint for cross-border initiatives, T.I.P. intensified the conduct of home- or campus-based internationalisation over cross-border education through the incorporation of international dimensions in the curriculum and learning process. Without the need to go out of the country, international learning experience is provided through:

- **Aligning programmes to meet international standards:** All engineering and computing programmes are accredited by Accreditation Board for Engineering and Technology, Inc. (ABET), a U.S.-based accreditation agency. T.I.P. is also an ASEAN University Network-Quality Assurance (AUN-QA) associate member. AUN is an international organisation that promotes regional cooperation among HEIs in Southeast Asia and around the globe, focusing on student and faculty exchange, promoting ASEAN studies, information networking, and collaborative research.

- **Integration of international teaching and learning materials:** This is done in selected programmes with the help of Cisco, SAP, Oracle, and ICDL, among others.

- **Joint projects with international content:** International partnerships allowed T.I.P. students and faculty members to collaborate with the California Polytechnic State University (Cal Poly) [2], Jeju National University (JNU) [3], and Chung Yuan Christian University (CYCU), among others.

- **International conferences, seminars, and workshops:** These give larger T.I.P. students groups an opportunity to listen to lectures given by international resource speakers.

- **Visiting professors from international academic partners:** Visiting professors are tapped to conduct lectures on specialised topics in selected professional courses.

Cross-border education activities involving the mobility of students, faculty, and researchers are limited to benchmarking activities and student exchange for internship.

Benchmarking activities with foreign universities is undertaken to learn international best practices, including new technologies and innovative approaches (e.g., outcome-based teaching and learning), from the City University of Hong Kong [10], Melbourne University [4], the University of Sydney [5], and Monash University); novel student services (e.g., Career Services of Stanford University and UC Berkeley); and innovations adapted to the culture and core competencies of participants (e.g., Technopreneurship of the National University of Singapore and UC Berkeley).

T.I.P.'s vice president for academic affairs is among the 39 college and university administrators and government official from 22 countries who participated in the inaugural round of the Education USA Leadership Institutes to increase understanding of U.S. higher education and provide a unique opportunity for reciprocal knowledge exchange between the U.S. and participating countries.

The T.I.P career centre director recently went on a benchmarking visit to Standford University and UC Berkeley to gather more insights and career centre best practices, with the aim of further strengthening the capability of T.I.P in managing its own centre [11].

Key T.I.P official also embarked on benchmarking visits to top-ranking universities in Australia such as the University of Melbourne, the University of Sydney, and Monash University. They also met with experts from the Institute of Engineers Australia [8], Assessment Research Centre, and Australian Council for Educational Research (ACER) [7]. The visits allowed them to develop their capability in competency- or outcome-based education. They also identified good practices in developing outcome-based education teaching and learning systems and established network connections with the HEIs they visited.

Another team of key T.I.P. official went on a benchmarking visit to the City University of Hong Kong to learn about implementing outcome-based teaching and learning. The best practices are now being used as templates to fully implement the approach. Another benchmarking visit was conducted to learn about the university's facility for interactive teaching and learning [10].

Members of the T.I.P. Academic Council visited the George Washington University and learned best practices on student services and graduate programme administration.

T.I.P. also became a signatory partner of the SEAMEO SEA-Teacher Programme in 2016 [5]. Since then, it has been actively involved in sending and hosting student interns to and from universities in Thailand and Indonesia.

Challenges Faced in the SEA-Teacher Programme

As mentioned earlier, lack of financial capacity is a major challenge for outbound students of T.I.P. Thus, the number of students applying for internship in the SEA-Teacher Programme is very minimal. Security risk is another barrier for students who are deployed as interns in foreign countries that are susceptible to manmade and natural calamities. Parents are hesitant to send their children for fear of their safety. Language barriers are also a problem for inbound students who have difficult communicating in English. Gender issues are another constraint for inbound students because T.I.P. has no facility for mixed-gender housing. Students of diffe ent genders cannot be accommodated within the same apartment. Therefore, only exchange students of the same gender can be accommodated at a given time.

T.I.P. Implementing Guidelines for the SEA-Teacher Programme

With the relatively short period of participation in the SEAMEO SEA-Teacher Programme, the following implementation guidelines have been adopted:

- A more rigid screening process for inbound and outbound students to ensure that only those who are intellectually and emotionally mature and financially capable a e considered
- Pre-deployment orientation for all outbound students
- Orientation on the Filipino culture and crash course on conversing in English for inbound students
- Provision of a dedicated student buddy and faculty mentor for each inbound student

- Tapping student organisations to assist international students in adjusting to the Filipino culture
- Participation of inbound students in local cultural trips and other related activities

Conclusion

T.I.P.'s participation in the SEA-Teacher Programme opened opportunities for local and international employment with attractive compensation packages for its graduates. In a February 2018 ***Jobstreet*** survey, T.I.P. placed seventh among the schools most preferred by employers to hire fresh graduates from [9].

Realising the benefits of academic mobility, T.I.P. commits to improve opportunities through better assessment and evaluation results, formal internal monitoring, and external reviews. It will continue to explore possible sources of funds to allow more students to participate in the SEA-Teacher Programme. It also hopes to expand its cooperation with international partners with the end view of strengthening student competence and enhancing academic learning and performance through academic mobility.

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Improving Academic Competence and Global Engagement: Student Participation in SEA-Teacher and SEA-TVET

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Abstract

This article presents UPI's involvement in the two student mobility programmes organised by SEAMEO, namely, SEA-Teacher and SEA-TVET. SEA-Teacher aims to provide opportunities for pre-service student teachers from universities in Southeast Asia to obtain teaching experience (i.e., practicum) in schools in other countries in the region. Meanwhile, SEA-TVET aims to promote technical and vocational education and training (TVET) student and staff exchange, which includes cross-country industrial attachments and internship programmes. Basically, SEA-Teacher and SEA-TVET consist of three main activities—orientation, implementation, and reporting. The benefits of joining the programmes include improving students' content knowledge and pedagogical skills, competence, and qualifications; harmonising curricula and forming industrial linkages; and enhancing students' English language skills and global engagement. UPI also discussed challenges it faced in the programmes such as short duration and lack of English proficienc .

Keywords: Student mobility, SEA-Tecaher, SEA-TVET, global engagement

UPI and Global Engagement

Since its establishment in 1954 as one of the educational institutions in Indonesia, UPI has become a leading HEI in the country that consistently focuses on teacher education. In 1998, UPI transformed into a comprehensive university, enabling it to administer both teacher education as its core business and non-educational programmes. Its teacher education programme focuses on the foundation of education, pedagogies, subject matters, pedagogical content knowledge, teaching practicum, and research. Its non-educational programme, meanwhile, consists of foundation courses, subject matter courses, internship programmes, and research.

With its vision to become a leading university, UPI identified some missions (Peraturan Pemerintah RI, 2014), namely:

- Providing quality education
- Conducting research rooted in local wisdom
- Developing teacher education
- Disseminating experiences and innovations for the development of the society

In the academic area, these missions are implemented in the form of general learning outcomes such as:

- Building scientific, educative, and eligious attitudes
- Developing a sharing and caring personality in the workplace and in one's social life supported by global competitiveness and comparativeness
- Adapting to dynamic changes
- Developing good citizens with national, regional and global views
- Integrating skills such as learning and innovation, mastery of information, media and technology, career and life
- Becoming lifelong learners

The above-mentioned learning outcomes are designed so that students can face the challenges of internationalisation that exist today in the ASEAN Economic Community (AEC). Based on the blueprint of AEC in 2015, the education sector plays a significant role in building AEC by strengthening the implementation of its economic initiatives; accelerating regional integration in priority sectors, especially by facilitating the movement of business persons, skilled labour, and talents; and strengthening the institutional mechanisms of ASEAN. The education sector also plays a significant role in building the ASEAN sociocultural community by developing and strengthening the coherence of policy frameworks and institutions to advance human development, social justice and rights, social protection and welfare, environmental sustainability, ASEAN awareness, and narrowing the development gap (ASEAN, 2008).

A deeper look at AEC reveals that it focuses on a single market and production base, which has five "free flows" as core elements (i.e., goods, service sector, investment, capital, and skilled labour). ASEAN works towards regional harmonisation and standardisation by enhancing cooperation among the members of the ASEAN University Network (AUN) to increase mobility for both students and staĀ within the region and developing core competencies and qualifications for the job/occupational and trainer skills required in priority service sectors.

In response to the challenge put forth by AEC and as one of the institutions in ASEAN, UPI is responsible for promoting knowledge of resources and sociocultural policies among universities across the region. The university also has the responsibility to contribute to and actively participate in developing synergy for institutional and regional mobility programmes. This is in line with a more global initiative by UNESCO, which declared global citizenship education (GCED) critical. This initiative requires students to immerse in technology-cultivated, autonomous and global-oriented yet local wisdom-rooted education. The programme promotes the idea of global or world citizenship by promoting equity in education for all students across the world.

One focus of GCED is transversal competencies such as intrapersonal and interpersonal skills, global citizenship, media and IT skills, creative and innovative skills, and others. These competencies need actual practice in global interactions to support global engagement. Students in HEIs are future global citizens who have the privilege to become future leaders. As the world becomes smaller and global, they should have global worldview and embrace the spirit of global citizenship. Since the shrinking world is becoming more diverse, they should embrace values such as tolerance, understanding, partnership, and collaboration.

On the other hand, ASEAN also has a mission to build awareness of ASEAN; develop the ASEAN identity; and cultivate qualified, competent, and well-prepared ASEAN labour forces. This mission is implemented in the form of SEA-Teacher and SEA-TVET.

As such, UPI aims to develop good citizens with national, regional, and global visions by contributing to and actively participating in SEA-Teacher and SEA-TVET. This is in support of UNESCO's global and ASEAN's regional initiatives to increase student involvement in global activities to turn them into future global citizens and leaders.

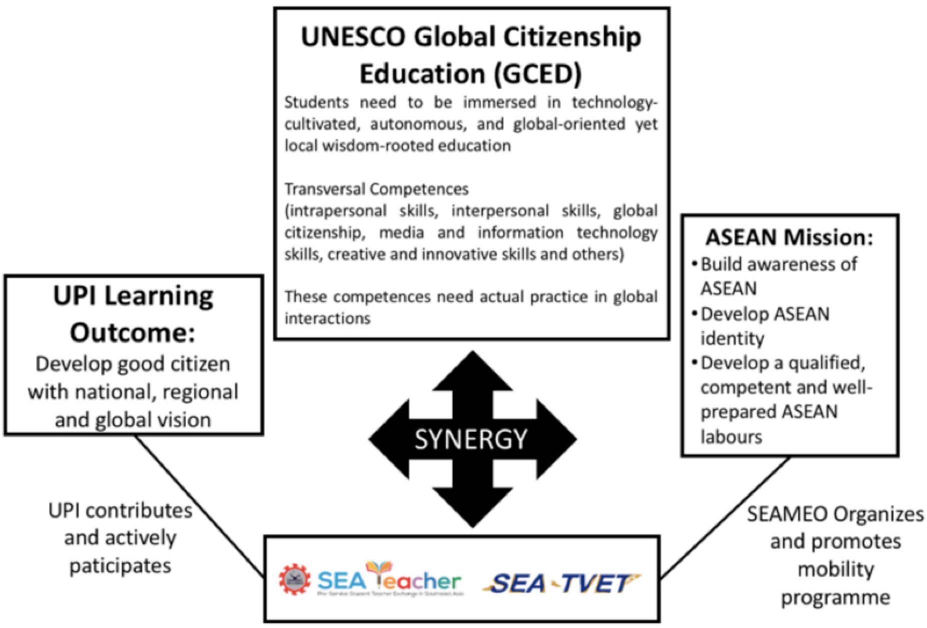


Figure 45: Synergy of institutional and regional mobility programmes

SEA-Teacher and SEA-TVET

SEA-Teacher aims to provide opportunities for pre-service student teachers from universities in Southeast Asia to gain teaching experience in schools in other countries in the region. It responds to SEAMEO Priority Area 5—Revitalising Teacher Education (SEAMEO, 2015). Its objectives include to develop pre-service student teachers's teaching skills and pedagogies, encourage them to enhance their English skills, give them broader regional and world views, expose them to diverse teaching and learning situations and opportunities, and encourage them to become fl xible.

Meanwhile, SEA-TVET aims to promote TVET student and staff exchange, which includes cross-country industrial attachments and internship programmes. It responds to SEAMEO Priority Area 4—Promoting TVET. Its objectives are to foster networking among TVET providers, provide opportunities for participating institutions to work together through student and staff exchange and industrial attachments, and share best practices and generate new and innovative ideas through research collaborations. It will improve TVET standards and competencies in Southeast Asia through internationalisation and harmonisation. It also aspires to promote and develop curriculum harmonisation, along with the internationalisation of study programmes through lecturer/student exchange, joint research, and industrial linkages. Finally, it hopes to create a sustainable networking platform for the use of TVET leaders and institutions, industries, and related development agencies in the region. SEA-TVET has six main activities—student exchange, staff exchange, industrial attachment for students, industrial attachment for staff, sharing expertise and resources, and research collaboration. It focuses on several industries—hospitality and tourism; electronics, mechatronics, and manufacturing; agriculture and fishe y; construction; and other areas (as long as partners are available) (SEAMEO, 2016).

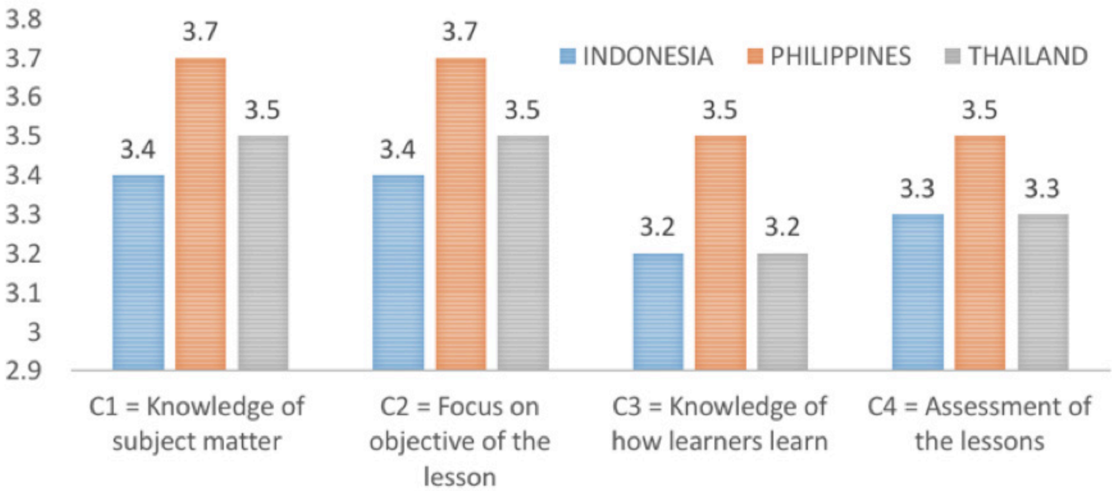
Basically, SEA-Teacher and SEA-TVET comprise three main activities—orientation, implementation, and reporting. During the orientation session, the participants are introduced to campus life, the school culture, the industry, and the culture of the place they are visiting. In the implementation session, the participants usually conduct teaching observations, develop lesson plans, undergo teaching practice, and form industrial linkages. The last stage is reporting where the participants are required submit daily reports, presentations, and a final report in the form of a blog (SEAMEO, 2018).

Figure 46: Steps in SEA-Teacher and SEA-TVET

SEA-Teacher provides benefits students by allowing them to learn diffe ent teaching skills and pedagogies, including how to make lesson plans for these; know about diffe ent school situations; improve their English proficiency; give them an opportunity to make friends with people with diverse cultural backgrounds; and learn about local cultures. Meanwhile, mentors benefit in that they become more familiar with diffe ent teaching skills and pedagogies that can lead to curriculum adjustments and internationalisation; identify real linkages between industries and universities, which leads to curriculum harmonisation; improve their English skills; and become more confident in interacting with international students.

Countries	Batch 1 Jan-Feb 2016	Batch 2 Jul-Aug 2016	Batch 3 Jan-Feb 2017	Batch 4 Aug-Sep 2017	Batch 5 Jan-Feb 2018	Batch 6 Aug-Sep 2018	Batch 7 Jan-Feb 2018
Indonesia	12	56	89	132	170	207	292
Malaysia	-	-	-	-	-	3	
Philipines	-	5	26	26	92	84	
Thailand	10	40	81	41	110	133	
Total	22	101	197	265	343	427	712
Number of universities involved	**2**	**7**	**27**	**41**	**57**	**79**	**87**
Number of UPI student involved	-	8	12	11	8	9	18

Figure 47: Participating countries, institutions, and students in SEA-Teacher Batch 6



Source: Documents of Program Evaluation SEA Teacher Batch 6

Figure 48: Evaluation results for SEA-Teacher for content and instruction organisation training

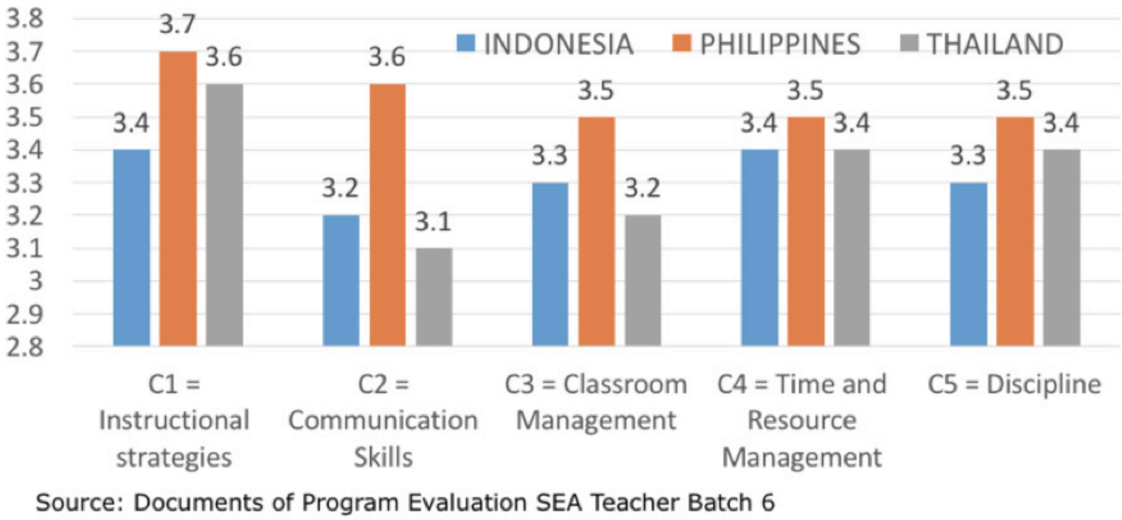


Figure 49: Evaluation results for SEA-Teacher strategies and skills for effective instruction t aining

Similar to SEA-Teacher, SEA-TVET also benefits not only students but also univeristy lecturers and industry mentors. The students learn not only technical know-how but also experience living and "working" abroad, which enables them to learn new languages, adjust to various cultures, and obtain other regional experiences.

The teachers who participate in staff exchange also benefitin that they gain experience in living and "working" abroad and connect with teachers in the region. Teachers who work in host institutions gain experience in serving international students.

Institutions such as secondary TVET schools, vocational and technical colleges, and polytechnics that participate in SEA-TVET also enjoy benefits like expanding their network, learning from the good practices of fellow institutions in the region, and gaining an opportunity to partner with various institutions for student and staff xchange.

Participating in SEA-TVET also enhances industry performance of the industry in that they cultivate students and staff members who are more knowledgeable about current industrial requirements. As such, they also gain future workers who can perform jobs in multicultural working environment.

Challenges and Proposed Solutions

Participating in SEA-Teacher and SEA-TVET are, however, not without challenges.

First, the program duration may be too short probably to avoid visa requirements. But one month may not be enough for participants to gain enough experience, especially for SEA-TVET. Some industries suggest an extension to 2–3 months. In the future, maybe SEAMEO can make arrangements with ASEAN foreign ministers to forgo visas for participants to promote the mobilisation among students and staff members. Possibilities for credit transfer between ASEAN universities can also be considered.

Second, many participants have limited English proficienc . As such, they cannot fully communicate with peers. Sending institutions must exert more effo t to improve their students' and staÃ's language competency. Only by learning English can they truly gain knowledge and experience from SEA-Teacher and SEA-TVET.

Conclusion

Both SEA-Teacher and SEA-TVET are beneficial to students in terms of content knowledge and pedagogical skills, competence and qualification, curriculum harmonisation and industrial linkage, English language skills, and global engagement. As such, the more ASEAN countries and institutions participate, the greater the benefits. We also hope that HEIs outside the region, including those in Japan, Korea, and China (AEC Plus 3), join the programmes so participants can have wider job opportunities. Last but not least, to sustain the framework that SEA-Teacher and SEA-TVET built, independent university partnerships are highly encouraged so more students can have more opportunities for exchange and mobility.

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