Integrating STEM and Skill Development (SD) for Thailand 4.0—Means, Methods and Challenges

Kuldeep Nagi
Fulbright Fellow (USA)
Assistant Professor
Assumption University
Bangkok, Thailand

Email: knagi@au.edu

Abstract—Formal education is mostly focused on training the mind through the acquisition of information and knowledge. Skills, on the other hand, are acquired through physical training and practice, turning finally into a unique habit, a product or a service. Lately, there is a lot of discussion about skill development (SD) to meet the goals of digital economy and Thailand 4.0. Using data from the World Economic Forum (WEF) and analysis of SD trends in the USA, UK and Germany, this paper provides insight into how Science-Technology-English-Math (STEM) education can be used to enhance skill development (SD) urgently needed to meet the challenges of Thailand 4.0.

Keywords—Community Colleges, University Extension Programs, Skill Development, STEM, Thailand 4.0

I. INTRODUCTION

There are various ways of differentiating formal education from Skills Development (SD). Put simply, education comes through academic studies but the skills are developed through rigorous training or practice. There are other key differences. Education may be forgotten over a passage of time, whereas, a skill is rarely forgotten. Education is like software (erasable) and skill is like hardware (non-erasable). In education, the mind plays a key role. In the case of skills, cognitive, human senses and motor skills play the lion's share. Education is mainly aimed at acquiring knowledge but skills represent competencies. Although different, they are the two sides of the same coin. In a nutshell, they together represent knowing and doing or know-how and do-how? Both of them (Figure-1) are needed in order to achieve success in a chosen career or a profession or in life, in general. The close, continuous and active interface between the two also enhances the Lifelong Learning (LLL). According to the World Bank Report of 2016, broadly speaking, there are three types of skills [1].

1. Cognitive skills include literacy and numeracy. They refer to the ability to understand complex ideas, adapt effectively to the environment, learn from experience, and reason.
2. Socio-emotional skills refer to the ability to navigate interpersonal and social situations effectively and include leadership, teamwork, self-control, and grit.
3. Technical skills refer to the acquired knowledge, expertise and interactions needed to perform a specific job, including the mastery of the materials, tools and new technologies.

This paper provides some background about how during industrial revolution of early 19th century, the United States created various channels for SD to meet the demand of new industries [2]. The advent of the internet in 1980s and thereafter the evolution of the new digital economy has led to drastic changes in the means, methods and models of SD. This paper identifies some of the means, models and methods currently used for SD. More specifically, in a local context, it tries to identify new options as well as challenges that lie ahead for SD to meet the goals and aspirations of Thailand 4.0.

Figure-1: Human Resource Development for Digital Economy

A. Thailand 4.0

In the last few decades, SD has been evolving with rapid changes in the Thai economy. Thailand 1.0 emphasized the agricultural sector and Thailand 2.0 emphasized the role of small industries. In the beginning of the 21st century, Thailand 3.0 was introduced which largely focused on deploying heavy industries, while Thailand 4.0 focuses on a "Value-Based Economy." For attaining these goals, the government is taking a number of measures to shift the country from a production-based economy to a high value service-based economy [3]. The main thrust of this new initiative is to move away from producing commodities to new products, promoting new technologies, creativity, and innovation in Thai industries. Another objective of Thailand 4.0 is to help the country escape the middle-income trap and growing income disparity in society.
Thailand 4.0 is based on a 20-Year National Strategy intended to help the country achieve sustainable development. Also referred to as the “6-6-4 plan”, it consists of 6-target areas, 6-primary strategies and 4-support strategies. The 6 target areas include security, competitiveness enhancement, human resource development, social equality, green growth and public sector development. However, focus on reforming education for SD is missing in this plan. For all practical purposes, the STEM covers four major domains- Science, Technology, Engineering, and Math. In Thai context, the deficiency in English language often replaces the “E” (Engineering) in the acronym STEM.

In 2014, a brief report by World Bank titled ‘Jobs and Skills: World Development Report 2013’ provided a “Skills toward employability and productivity (STEP)” framework [1]. This report detailed a system for workforce development based on the job market in different countries. The fundamentals of such a system are relevant (Figure-2) for Thailand 4.0 because of forces of demand and supply of skilled labor.

**Systems for Building Job Relevant Skills**

A workforce development system influences both skills Demand and Supply

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**Figure-2: Skill Development- Supply vs. Demand**

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**II. LITERATURE REVIEW**

In 2014, Ahonenand and Kankaanranta published a study in Finland which utilized online tools in the Assessment and Teaching of 21st Century Skills (ATC21STM). Since then the acronym ATC21STM has been globally trademarked [5]. This development process was implemented as international project through four phases, namely concept checks, cognitive laboratories, pilot studies and trials. These phases were analyzed from the student’s and teacher’s perspective. It presented the experiences, possibilities and challenges of introducing and developing the tasks for 21st century skills in the Finnish schools across the nation. This project was later implemented in Australia under the National Curriculum, which included general capabilities to be taught across all learning areas including IT/ICT competencies and the ability to work collaboratively in teams, across cultures and disciplines [6].

In 2017, Ester van Laar and his team surveyed various research papers on SD for 21st-century digital skills that drives organizations’ competitiveness and innovation capacity. They found out that although such skills are seen as crucial, but the digital aspects integrated with 21st-century skills is not sufficiently defined [7]. This team conducted a systematic literature review to synthesize the relevant academic literature concerning with 21st-century digital skills. In total, 1592 different articles were screened from which 75 met the predefined inclusion criteria. The results show that 21st-century skills are broader than digital skills- the list of mentioned skills is far more extensive. In addition, in contrast to digital skills, 21st century skills are not necessarily underpinned by IT/ICT. Furthermore, they identified seven core skills- technical, information management, communication, collaboration, creativity, critical thinking and problem solving. Five contextual skills were also identified- ethical awareness, cultural awareness, flexibility, self-direction and lifelong learning.

Another study conducted by Hyewon Jang of Harvard University in 2016 showed that the framework for 21st-century skills and engineering education does not lead to creation of competencies expected in the 4 domains of STEM. In his study, the author identified important STEM competencies and evaluated the relevance of current frameworks applied in various educational systems using the standardized job-specific database operated and maintained by the US Department of Labor. His analysis of the importance of 109 skills, types of knowledge and work activities, revealed 18- skills, 7-categories of knowledge, and 27-work activities important for STEM workers. Implications for STEM education programs were also discussed, including how they can bridge gaps between education and important workplace competencies required in this new century [8].

According to Klaus Schwab, the Founder and Executive Chairman of World Economic Forum (WEF) based in Geneva, the Fourth Industrial Revolution may lead to greater economic inequality. The largest beneficiaries of technology innovations will be the providers of intellectual and physical capital-the innovators, shareholders, and investors-which explains the rising gap in wealth between those dependent on capital versus those dependent on labor. Technology is therefore one of the main reasons why incomes have stagnated, or even decreased, for majority of the population in high-income countries. Hence the demand for highly skilled workers will increase while the demand for workers with less education and lower skills will further decrease. The result will be that we will create a job market with a strong demand at the high and low ends, but will lead to hollowing out of the middle [9]. All the trends indicate that in the future, talent, more than capital, will act as a critical factor of economy. In this context, in Thailand, it may give rise to an economy increasingly segregated into “low-skill/low-pay” and “high-skill/high-pay” segments, which in turn may lead to an increase in social tensions.

Accreditation Board for Engineering and Technology (ABET) in USA has identified that for an engineering student enrolled in any American university, development of professional skills is of equal importance to developing technical skills [10]. Learning new skills of any nature requires formalization, facilitation, and feedback. However, the resources for teaching professional skills like teamwork knowledge, skills, and abilities (KSAs) are limited. Either they are incompatible to most educational settings, or are resource-intensive [11].
In recent years, engineering education literature has also shown a need for the increased emphasis in preparing students for professional practice. Several national organizations in USA have demonstrated this need through lists of skills and outcomes required by engineering graduates. Numerous factors have been linked to the development of these outcomes, both inside and outside of the classroom. For this study, the data were obtained from alumni though a nationally representative study of engineering programs. Findings of this work demonstrated the value of participation in such organizations and the relationship between career decisions and current and future skill development [12]. Another study provides the assessment of how Generation-Z students gain their understanding from classroom, from self-study or group-study at one of the university in Thailand. The results of this study illustrate that students ignore the lectures leading to decrease in classroom attention. This work also shows the need to change classroom activities to better serve students' learning styles [13].

### III. INTEGRATING STEM AND SKILL DEVELOPMENT

Different countries have used a variety of methods and models for integrating STEM into their SD aspirations. Before we discuss the SD model adopted by USA and other European countries since the industrial revolution, let us look at the current data from World Economic Forum (WEF) that shows a strong correlation between STEM based education and overall ranking on the World Competitive Index 2017-18.

#### A. Global Competitiveness Index 2017-18-Ranking of Thailand

The Global Competitiveness Index 2017-2018 issued by World Economic Forum (WEF) presents a framework and a corresponding set of indicators in 3 principal categories (sub-indexes) and 12 policy domains (pillars) for 137 economies or countries. As shown in Table-1, this year Thailand ranked 32 out of the 137 countries included in the list [14].

**Table-1 Thailand’s Global Competitive Index 2017-2018**

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<thead>
<tr>
<th>Overall</th>
<th>Rank/137</th>
<th>Score (1-7)</th>
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<tr>
<td></td>
<td>32</td>
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<tr>
<td>Basic Requirements</td>
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<td>5.06</td>
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<tr>
<td>Efficiency Enhancers</td>
<td>35</td>
<td>4.62</td>
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<tr>
<td>Innovation &amp;</td>
<td>47</td>
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<td>Sophistication Factors</td>
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The average score on 12 pillars was found to be 4.7 out of 7. The same report identifies that Thailand has inadequately educated workforce (Score=9.7/16). Since 2012 the overall score on all indexes (Table-2) in the last 6 years have not changed very much, it remains suspended between 4.5-4.7 out of 7. The score for local availability of specialized training services critical for SD also remain low 4.7. On the contrary, Singapore, one of the members of ASEAN is globally ranked as 4/137 with an overall score of 6/7.

#### B. Quality of Science & Math Education

As shown in Figure-3, among ASEAN members, Singapore leads the region for “Quality of Science & Math Education” score on the 5th Pillar of WEF Complete Index [9].

When it comes to Quality of Math and Science Education it is at the top (16th) in the world rankings. Thailand ranks 83/137.

#### C. American Model of Skill Development and Lifelong Learning

During the past couple of years, a surge has been observed in middle-skill areas that require post-secondary education instead of conventional education, such as, high school diplomas or a Bachelor’s degree. In 2016, in the USA, over 70 million people worked in middle-skill jobs. Middle-skill jobs include technicians, police, electricians, firefighters, plumbers, welders, dental hygienists, respiratory therapists, radiologic technicians, and many others. Middle-skill jobs are essential for

### Table-2 Thailand’s Global Competitiveness Index from 2012-2018

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<td>37/148</td>
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<td>4.7</td>
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**Figure-3: Scores on Quality of Math and Science Education (ASEAN)**

**Figure-4: Ranking on Quality of Math and Science Education (ASEAN)**
the US infrastructure development and overall economic growth. There is a growing demand for such jobs among millennials that have suffered from unemployment issues despite having college degrees. As these jobs cannot be outsourced, there is great demand for specialized skills required for these jobs [15]. Hence these demands are enhancing the role of vocational schools, community colleges and university extension programs for SD across the USA.

The community college based SD programs are expected to grow as they play a critical role in enhancing the employment-oriented skills of the young work force and preparing them for the rigors of the current job market dominated by new technologies, such as, Artificial Intelligence (AI), Cloud Computing, Big Data Analytics and Internet of Things (IoT). The history of the USA shows that the community colleges have always adapted during tough times to fulfill emerging demands of students and unemployed job seekers [16]. As shown in Figure-5, they act as hubs of imparting education to students with diverse needs and backgrounds at a lower cost than their counterparts, especially the private training institutions. In a nutshell, preparing students for middle-skill jobs has been a key component of the community college vocational and specialized workforce training programs.

![Figure 5: Channels of SD in USA](image)

In the USA, for most part of the last century, the SD has been an integral part of education sector. Various vocational and extension programs based in community colleges and universities have played a pivotal role in producing a skilled work force for the private sector. As depicted in the Figure-6, the success of extension programs requires a closer cooperation, not only at the regional level, but at the local levels as well. The success of these programs is a result of a continuous cooperation among local industry, research institutions and civic administration that goes beyond conventional limits.

![Figure 6: Triple Helix of Extension Programs](image)

Traditionally, the American economy has concentrated on development of specific competitiveness factors, such as, specialization of suppliers, education and training of work force, introduction of information networks and providing of responsible management. On the other hand, state administration or government is responsible for ensuring a stronger institutional and administrative support to the local economy, particularly when some decisions about investing in education and infrastructure have to be made, or when some internal regional problems have to be jointly solved. Triple helix model shown in Figure-6 is an empirical model that connects these 3-sectors which presupposes the transition towards knowledge based society. In order to redefine the interrelationship between institutional knowledge, economy and local administration (broadly speaking, the local government), it is necessary to focus on the enhancement of the local development conditions by linking college and university programs with other innovative activities. In the first stage of local economic development it is necessary to create a business environment and to encourage measures for concentration of innovative business activities. Two other stages, consensus and innovations comprise of ideas and strategies of multiple and reciprocal relationships among universities, local industries and administration.

With increasing demands of digital economy, the community colleges in the USA are also incorporating education technology (ed-tech) products and solutions in their campuses. This can be attributed to their efforts in improving the quality of education while maintaining the affordability of their programs. They have adopted online medium of delivering knowledge to their students and are planning to enhance their services to attract and retain students. As an example, the Department of Aeronautics and Astronautics of MIT has designed and developed Fly-by-Wire, a blended learning technology which will allow community colleges and students to install an Instructor App and Student App, respectively. With the help of the Instructor App, a teacher can assign homework and track the progress of students. Students can access homework through the Student App, which also guides and provides feedback, helping them to understand concepts.
In his paper based on the interviews of experts based in the USA, Sweden, Brazil, Italy, Portugal and Denmark, Henri Etkovitz describes the extension programs as second academic revolution, integrating a mission for economic and social development for transforming the traditional teaching and research university into an entrepreneurial university [17]. His Triple Helix thesis (Figure-6) postulates that the interaction among university-industry-government is the key to improving the conditions for innovation in a knowledge-based society. More than the development of new products in firms, innovation is the creation of new arrangements among the institutional spheres that foster the conditions for more innovations. Invention of organizational innovations, new social arrangements and new channels for interaction becomes as important as the creation of physical devices in speeding the pace of innovation. The underlying philosophy of the new system to “help people help themselves” by taking the university to the people. Most university extension programs have evolved to changing priorities and the needs and focus on providing quality information, education and training according to needs of the current job market.

Young people need a deeper understanding how to apply technology and innovation in order to achieve desired results. Thai education system, meanwhile, need to ensure technology curricula are kept up-to-date, and as mentioned above, the Thai teachers are given training to refresh their own knowledge and skills in order to keep pace with external developments. The use of technology should be embedded across the educational experience, to mirror the ways in which it is becoming relevant to all sectors and careers.

As noted in the World Economic Forum’s 2017 white paper, “Realizing Human Potential in the Fourth Industrial Revolution”, the educational curricula cannot remain fixed, as career paths change faster, and are less linear than ever before. There is wide-ranging consensus that no single skill set or area of expertise is likely to be able to sustain a long-term presence in the economies of the future. Educational institutions need to provide both in-depth subject knowledge, and ability to make inter-disciplinary connections. The Forum’s 2016 report “The Future of Jobs” noted that the core skills of the 21st century, such as, complex problem solving, critical thinking, creativity, collaboration, and digital literacy are important for enabling people to be flexible enough to adapt to changing needs of the job market. These skills are ideally developed early, in basic education, and then refined at colleges and universities as well as during lifelong learning.

Future-ready curricula in Thai institutions must deliver a strong foundation in English, math, science and technological skills [18]. However, shifting demand for skills across Thai industries will require that curricula be updated and adapted on a regular basis, as they are largely dependent on the abrupt changes in labor markets. Upgrades to curriculum related to SD should be built into the system incrementally, thereby avoiding the disruption and time-lag associated with major, infrequent overhauls. To ensure that Thai education remains job-relevant, it is critical that more emphasis is placed on collating insights from government, businesses and civil society in the curriculum design process. Existing institutions in Thailand lag in their means, modes and models and may not be able to effectively respond to the pace of change created by new digital economy, or to its relatively demanding nature [19]. Hence more global collaboration on solving SD related problems could ensure a sustainable and inclusive digital future.

IV. RESULTS & DISCUSSIONS

In Thailand, most jobs of the future will require a basic understanding of math and science. Digital economies require an increasing implementation of engineering and new technologies. Given the importance of STEM in the growth of future workplaces, it is important to ensure access to related education to all socio-economic groups. Girls and the women are particularly underrepresented in Thailand within high-value-added STEM disciplines. Hence it is crucial to find ways to increase their participation. This section further explores how SD is being managed in UK and Germany.

A. Digital Literacy and STEM Skills in Thailand

Technology is rapidly altering the ways we interact and work. Young people in Thailand therefore need to develop digital fluency and STEM skills from an early age if they are to be equipped to thrive in the modern workplace in ASEAN.
Colleges, National Skills Academics and private and community training providers. Clearly, educational institutes have been at the heart of vocational education in the UK.

The German dual model is essentially a combination of theory and training implanted in a real work setting. It is engrained in the education system and is driven by industry and trade unions, who constantly upgrade and modify training modules and job roles. These are generally two to 3 year programs and students divide their time between working in a company and learning theory at a vocational school. The companies (mostly small and medium size) provide training to students in nationally recognized occupations. These occupations are certified by either a chamber of commerce or crafts or trades. In the German model, universities provide classroom-based theory and skill knowledge partners provide on-job training. Another arm is the Vertical Anchor, which does skill gap analysis, geographic mapping and curriculum and content creation. The process of quality control is performed by universities by ways of approving the curriculum, aptitude assessment, examination and certification. The educational institutes acts as the facilitator of the ecosystem. They provides a 3 year BVoc degree, diplomas and certificates to participants, allowing multiple exit points after each year.

The current crisis in skill development in Thailand is a natural consequence of a segregated system that wants to churn out numbers but not quality. However, since Thailand higher education has failed to deliver on its mandate to provide quality education, it could be a reason for the country to experiment with newer models of education that will have more autonomy to forge industry partnerships and innovate with teaching methods. In such a case, it is imperative for any skills institute to have a work-integrated model where students learn by doing. Unlike the UK’s FE colleges, Thailand doesn’t have bridge institutes that train students for professional careers. Which is why it would be worthwhile to look at the UK’s and Germany’s main focus- apprenticeship.

C. Recommendations for Skill Development

Improving education proficiency requires lots of investment in fundamentals including school reforms. The current Thai government has championed the idea of associations in developing effective experience based education programs, both at vocational and college levels as a part of national agenda. The proof of return on investment (ROI) and more incentives are now driving the SD programs. There is an increasing awareness that SD program should also be managed by professional third party to achieve a WIN-WIN-WIN (situation for all the 3 stake holders- the educational institute, private sector and students. Thailand Productivity Institute (TPI) should play more active role in transforming Thailand 3.0 to 4.0 by creating innovative and creative programs based on industry benchmark and needs. It is high time Thailand learns from successful global models of skills education, including from the USA, UK and the Germany and implements them in their true spirit with the highest degree of autonomy. There are many lessons to be learned and Thailand must be selective based on what it aims to achieve and how it wants to do so.

Aimlessly creating a fragmented system of skills will only lead to more unemployed and underemployed population that will damage the country’s economic growth, rather than accelerating it. It is desirable that the Government of Thailand expand the purview of the SD to the institutes of higher education as well, which are currently under the Office of Higher Education Commission (OHEC). OHEC should introduce Bachelor of Vocation (BVoc) and Diploma in Vocation (DVoc) courses in several colleges and universities around the country.

Besides, any upcoming skills universities in Thailand should consider building a governance structure that will allow such external affiliations. Under the present norms such a partnership is constrained and any institute wanting to function under the nomenclature of a university will have to adhere to OHEC rules and that are restrictive and regressive. Since such a model will require timely update of course content and reforms in training methods, the academic council of the institution or university should be independent enough to make these prompt changes, without having to approach OHEC or any other regulatory or government body each time changes are required-unlike in the present Office for National Education Standards and Quality Assessment (ONESQA) system of quality assurance. Although setting up universities and rolling out skills schemes are capital-intensive activities, it is important to understand that a one-time investment needs to be supplemented with sustainable efforts to make the system self-sufficient. Any transformation in the job market may mean a timely and periodic upgrade of such labs and other facilities, which can cost huge sums of money to the institute. Fortunately, the Thai government has enough funds disbursed to universities for implementing skills initiatives by adopting innovative models of vocational education and training.

CONCLUSION

New technological innovations are rapidly transforming education, and are forcing updating of skills required for the workplace dominated by IoT, Big Data, AI, and Robotics. Building future-ready education systems requires designing curricula for the 21st century. It should be coupled with the consistent delivery of a basic education for everyone that leads to building a solid foundation for a lifetime of adapting and developing new skills and abilities. More specialized training for SD are needed in Thailand to provide in-demand skills, and address the disconnect between employer’s needs and existing traditional model of teaching and learning in schools and colleges in order to prepare a skilled work force for Thailand 4.0. At present, Thailand 4.0 mission is blowing at full steam. Thailand has adequate resources for skills fresh entrants in the next four years, by 2022. Higher education in the country is going through a phase of reforms where the government is making efforts to internationalize the system as well as make Thailand institutes globally competitive. Skills being a major point of focus, the current governments is attempting to create separate skills initiatives that will cater specifically to vocational education. Traditionally, in Thailand vocational
schools and colleges have been responsible for imparting vocational education and training in the country. Although there is enough funding to Thai universities the results shows that higher education system has been aloof from the skills ecosystem so far. Thus, it is time for Thailand to experiment with new models.

REFERENCES


