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Teaching Science for Thai Teachers in the 21st Century

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Advancement in science and technology, neurology research outcomes, and reactions on 21st century learning skills showed strong effect towards paradigm shift in the education business. Education administration in all levels places the focus on developing higher order thinking skills for the learners including creativity, problem-solving, analytical thinking, etc. as well as communication skills, using technologies at hands for knowledge seeking, and socializing skills. Therefore, education administration current trend needs to exploit holistic integration of interdisciplinary and practicality in real life that will lend more meaning for learners to see benefits, values, and practicality of learning. So, learners can put knowledge into practical use benefiting their daily living that enable them to become ready for pursuing higher education. This can lead learners for better chance of job opportunities in the future and also the value added and empowerment to the country economy.

Key words: Teaching Science, the 21st Century, STEM Education

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INTRODUCTION

The world of education has undergone changing tremendously in the 21st century. The tools for knowledge seeking play more crucial roles than the knowledge content. Technology advancement allows learners' control for self-activated learning through many available learning sources at their own pace of time. So, classroom atmosphere is apparently deviated from the traditional ones where learners holding laptop, tablet, iPad, and extensive types of smart phones. Teachers in this circumstance therefore need to change their role from knowledge transmitter standing in front of the class to teachers as facilitators stimulating and facilitating conveniences in learning in order to empower their learning at the maximum capacity. Through this education paradigm shift, the conceptual framework for education has also been transformed. So, this paper aims to present 4 issues based on the concept of STEM Education and the outcome of implementing STEM Education in oversea countries. Also being presented is components of knowledge and skills for 21st century

education, and guidelines developing 21st century learning for Thailand education through STEM Education.

Definition, Concept, and Characteristics of STEM Education

STEM Education is an interdisciplinary integration of various disciplines including Science(S) Technology (T) Engineering (E) and Mathematics (M) that harmoniously incorporates distinct features and teaching methods of each discipline in order that the learners implement knowledge of every disciplines in problem-solving, researching, and developing many innovations by means of interdisciplinary learning management from teachers of different disciplines working together. This is because working and living in the real life needs the interdisciplinary integration not the disintegrated knowledge. In addition, STEM Education promotes development of vital skills in accord to globalization or skills needed in the 21st century (Dejarnette, 2012; Wayne. 2012; Breiner, Harkness, Johnson, & Koehler, 2012).

Learning instruction based on STEM Education composes of the following characteristics (Dejarnette, 2012; Wayne. 2012; Breiner, et al., 2012).

1. Interdisciplinary Integration refers an integration of various disciplines including Science(S) Technology (T) Engineering (E) and Mathematics (M) that harmoniously incorporates distinct features and teaching methods each discipline. That is:

- Science (S) places an emphasis on understanding of nature. Educational practitioners advise teachers to use Inquiry Based Science Teaching and Scientific Problem-based Activities which rather match with primary students than secondary or tertiary students as this might cause boredom and disinterest to learners. However, teaching Science based on STEM Education attract students' attention and activate their enthusiasm and challenge leading students an increase on confidence and gaining success in learning high level of Science.
- Technology(T) is a subject involving process, problem-solving, improving, and developing elements or processes in order to meet the needs of human through technological processes entitled Engineering Design or Design Process which is similar to inquiry-based method. So, technology is not limited to only computer or ICT as normally perceived by the public.
- Engineering (E) is the subject involving thinking, creating, and developing innovations by students employing knowledge in Science, Mathematics, and Technology. People normally think that this subject is difficult to learn but research studies showed that even kindergartens can handle this subject successfully.
- Mathematics(M) is the subject not only involving counting numbers but also covering other vital components, first, Mathematical Thinking involves comparing, classifying/categorizing, patterning, and describing. Second, mathematical language involves children communicating thoughts or concept in mathematics using mathematical language such as more than, less than, smaller than, larger than, etc. Third, promote Higher-Level Math Thinking based on doing activities, playing toys or performing daily life activities.

2. Integration friendly for all class levels from kindergarten to high school. It has been found that the US mandated STEM as educational policy for all states. The findings indicated that teachers using Project-based Learning, Problem-based Learning, and Design-based Learning could apparently excel students in creating and developing works. In addition, the more teachers implementing STEM Education, the quicker learners enhance their ability and potential. Some states in the US have already implemented STEM Education at the preschool level.

STEM Education illustrates clear integration of 4 disciplines as aforementioned; however, it also incorporates Context Integration that involves daily life activities. Like this, it makes teaching meaningful to the learners and allows learners to see the values of learning and brings learning to benefit their daily life. So, this can lead to the value added and empowerment to the country economy.

3. Promoting learners' comprehensive development based on 21st learning skills.

- Cognitive skills refers to learners' comprehension of learning content
- Thinking skills refers to learners' developing higher-order thinking skills such as analytical thinking, creative thinking, etc.
- Teamwork skills refers to learners' ability in team working, effective communication, leadership, and open-minded for criticism and different opinions.

So, educational practitioners view integration of other disciplines for comprehensive STEM Education encourages true comprehensive learners' development. For example, STEAM Education plus Art (A) allows learners' expression or application of concepts for better creativity and imagination. Learners are able to communicate their own thoughts in the forms of music and motion using communication through language and gestures or painting or simulated model which give the works aesthetic and beauty characteristics for completeness in usage and beauty. In addition, STE2AM Education incorporating Ethics (Ethics: E2) activates learners' awareness on morality and ethics which is one of vital components nurturing a learner to become a good person.

Needs and Outcome of STEM Education Implementation in Overseas

STEM Education perhaps began from USA as it was found out that the country capacity in various dimensions were incompatible with other developed countries. The findings indicated that assessment outcome of students based on Program for International Student Assessment or PISA and test outcome on Trends in International Mathematics and Science Study or TIMSS of students in USA were lower than students from many other countries. According to this, the scores on Science and Mathematics indicated the decline of education administration in 2006 when compared to that of 2003. Also, report by Phi Delta Kappan revealed that students in the US performed low score on Maths problem-solving prompts (Bellanca & Brandt, 2010; Dejarnette, 2012). In addition, students with interests on Science and Mathematics were in the reduced numbers. Working population on Science and Technology and Engineering was also in the declining numbers. The findings also indicated that top-notch working population holding Ph.D. in Science was foreigner rather than the American. This apparently means inadequate human resources which lend negative effects on the economy. Therefore, STEM Education policy was introduced to alleviate the perceived problems with expectation in upgrading various types of assessment outcome such as PISA and therefore uplift population quality and unlock ties on other problems in the country. (Rachel, 2008)

Implementing STEM Education policy into practice, the US government allocated large amount of budget for schools in nearly 40 states (National Research Council of the National Academes, 2011). In addition, the government announced Education to Innovate Plan in order to stimulate STEM Education concrete implementation by exploiting various strategies such as developing prototype Maths, science, technology, and engineering teacher entitled STEM Master Teaching Corps. So, these educational practitioners are pioneering group in implementing STEM Education and promoting the growth of the STEM Education society. (Ministry of Science and Technology, Thai Embassy, Washington DC, 2012)

Apart from the US, other countries are now active and paying interests in STEM Education such as China, India, etc. Especially, China, in 2015, produced approximately 3.5 million bachelor degree graduates in science and technology or STEM degree not including master and doctoral graduates. These Chinese graduates account for more than 50% of graduates in this field worldwide. This figure clearly echoes the importance of STEM Education. Thailand education is also not excluded from this trend. The organization involved such as Institute for the Promotion of Teaching Science and Technology (IPTST) perceives the importance of STEM and undertakes the studies on approach in implementing STEM Education for teaching and learning. (ASTV Manager Online, 2013)

Components of Knowledge and Skills in 21st Century

21st Century Skills were the results from a meeting among scholars from various disciplines in the US as the government wanted to develop quality of population in an effort to uplift the country competitive capacity and expect the population to gain quality and potential in the society and therefore live in the world with rapid changes. So, components for 21stCentury Student Outcomes are knowledge, skills, and expertise include: (The Partnership for 21st Century Skills, 2009).

1. Core Subjects and 21st Century Themes refer to English, reading, rhetorical skills in using language, foreign languages, mathematics, economics, science, arts, geography, history, civic duties, and governance. This should also include other novel disciplines benefiting working and community works on which education institutions do not pay attention such as global consciousness, basic financial, economics, business, entrepreneurship, foundation on civilian, and health and welfare awareness.

2. Learning and Innovation Skills are:

- Creativity and Innovation refer to creative thinking, creative working with others, and creative application of thoughts.
- Critical Thinking and Problem Solving refer rationale thinking, systematic thinking, decisive thinking, and problem-solving.
- Communication and Collaboration focus on communication using various patterns based on effectiveness, clarity, and collaboration.

3. Information, Media and Technology Skills are

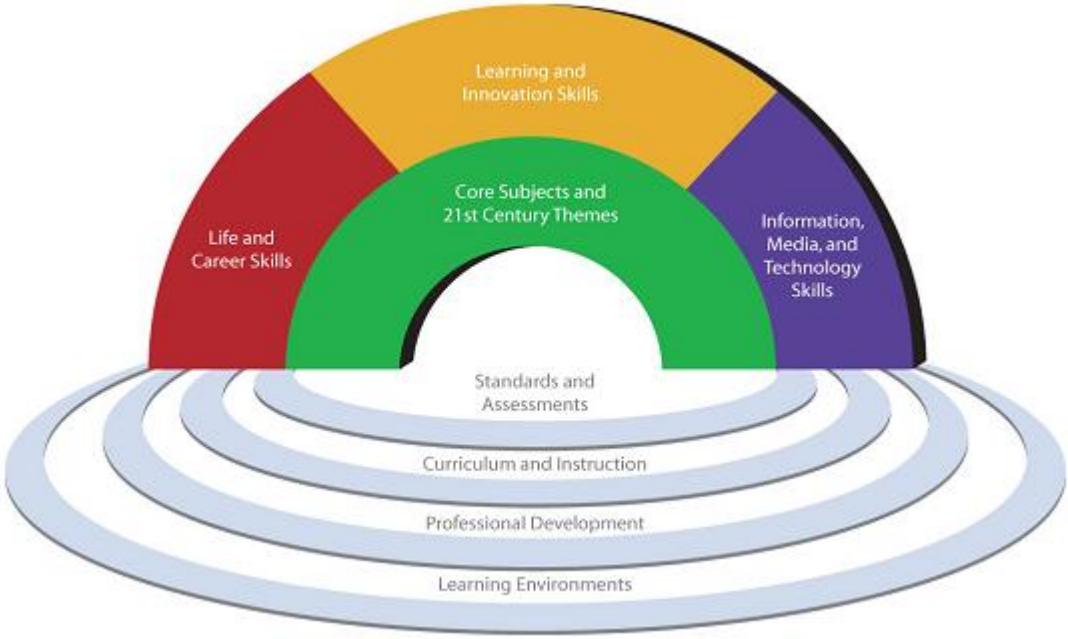

Figure 1. A Framework for 21st Century Skills
From : The Partnership for 21st Century Skills (2009)

crucial for students due to technology advancement in the 21st century.

These skills are:

• Information Literacy
• Media Literacy
• ICT Literacy (Information, Communications & Technology)

4. Life and Career Skills refer to living life and work not require only individuals' knowledge and cognitive competence but also require individuals who are capable to work under complicated context and the required skills for this are:

• Flexibility and Adaptability
• Initiative and Self Direction
• Social and Cross-cultural Skills
• Productivity and Accountability
• Leadership and Responsibility

Guidelines Developing Thailand Education based on STEM Education

Education administration in Thailand has undergone changes in various aspects including qualitative and quantitative. For example, the emphasis is on quality of teacher competence, reduction on learning content duplication, integrating scientific research outcome regarding neurology and psychology on human learning for application into education administration at every level whether it be basic education and tertiary education by conducting research and employing the findings in reforming quality education administration. Setup academic seminar drawing participation from all parties involved to stimulate education practitioners to take account on importance of STEM Education and implement the approach to activate the movement in education policy with emphasis on empowering learners' important skills in 21st century. Teachers also need changes in teaching methods with concentration on learner-centeredness and variety of teaching styles in order to build necessary skills in the 21st century especially thinking skills such as integrated teaching with emphasis on project-based, research-based, etc. Upon the changes following STEM Education trends can show readiness for Thai education in implementing STEM Education.

Implementing various approaches in reforming traditional education administration require Thai education practitioners, stakeholders, teachers, and administrators' comprehensive analysis and

understanding in STEM Education implementation in order to prevent misunderstanding that lends negative effects in future education administration or affects unsuccessful implementation. For example, many people perceive that STEM Education focuses only on teaching science and mathematics as found in regular curriculum. In addition, many people understand that STEM Education refers to researching and developing new instructional method promoting teaching and learning in specific discipline. Some people also view that STEM Education focuses mainly on core knowledge on science and mathematics while integrating technological and engineering knowledge for comprehensive acquisition. So, comprehensive understandings on STEM Education regarding advantages, research findings, and related components or factors are needed to be reviewed for successful implementation of STEM Education in Thailand (Rachel, 2008; Bybee, 2009; The Wheelock College Aspire Institute, 2010; Bybee, 2011; Rapporteur, 2011; Carr, Bennetti, & Strobe, 2011). These issues include:

1. Curriculum/lessons. STEM Education is interdisciplinary integration focusing on 4 subject areas including science, technology, engineering, and mathematics. So, STEM Education is perfect for successful implementation on basic education that empowers students to attain strong foundation before entering tertiary education. STEM Education in each states of the US is well designed on curriculum, learning content, and lessons that allow teachers of every level an access to search for media and learning resources. So, teachers can use learning content and media conveniently. Research findings were used for curriculum improvement and revision. Thailand's readiness on 4 subject areas for STEM Education implementation on core basic education curriculum B.E. 2551, only science (S), technology (T), and mathematics (M) appeared readiness for implementation except engineering (E) which was found implicitly embedded in in technology and science subjects. So, explicit and consistent readiness of each subject area is important guidelines for teachers' implementation into lessons. In addition, readiness on media, lessons, explicit assessment and evaluation is also considered important for STEM Education implementation in Thailand.

2. Professional Development. Teachers play crucial roles in successful STEM Education implementation. Success stories among schools in the US involved were the results of teacher preparation and training in order to empower teacher's teaching capacity. Thailand, Institute for the Promotion of Teaching Science and Technology, who is in charge of developing curriculum on science, mathematics, and technology, involves in implementation planning for STEM Education by organizing training for personnel in educational institutions, international conference, and inviting specialists for special education and research training. Effective teacher development plan allow school administrators and teachers clear understanding on STEM Education so they can implement STEM successfully. In addition, experts in higher education can play a role in developing teachers through mentoring system in order to help teachers in their community accurate knowledge and understanding. Teacher preparation process promote friendly learning environment and allow teacher to construct lessons that encourage students to take action on doing things themselves while teachers provide assistance on curriculum planning and scaffold teachers' confidence and positive attitudes towards STEM Education.

3. Preparing student teachers to become STEM Education teachers is important process. Research findings showed that one factor leading to failure in teaching science at primary level was teachers lacked confidence in teaching due to inadequate teaching background or knowledge in science. Students received very few experience in science but having been nurtured substantial knowledge on rules or science theories. Curriculum preparation for student teachers should focus on practices consistent with 4 subject areas such as experimenting and practicing scientific methods, skills and knowledge needed in 21st century. Like this, student teachers gain confidence in teaching. Education institution producing teachers should provide clear teacher production system in order to benefit student teachers and their organization such as planning teacher manpower needs for specific discipline in order prevent oversupply. Appropriate proportion allocation of teachers to students for quality of teaching. Coaching and mentoring system is also important to develop confidence on student teachers performing teaching practicum.

4. Institutional preparation refers to preparing educational institutions and school administrators for STEM Education implementation as this process requires professional administrators in order to accommodate the administration strategically. This process aims at developing classroom instruction and allowing participation of all parties involving in sharing ideas and administrating. School administrators must act upon a leader of change and maintain good relationship with family, community, and education institution. The leaders should be active and pay attention to the changes for development. The leaders should be ready for develop career advancement and ready for coordination and collaboration with others. The leaders should provide supports for classroom instruction and allow participation for outsiders to take roles in education administration.

5. Undertaking research studies in support and develop

STEM Education. Education practitioners undertake research studies in various aspects regarding STEM Education such as implementing STEM Education at kindergarten level in order to nurture cognitive development in children, cognitive development regarding engineering skills, using technological devices like iPad and tablet for developing STEM instruction. The findings indicated well development in kindergarten children (Aronin & Floyd, 2013). The findings suggested success in STEM Education implementation was the result of consistency with core curriculum, teacher quality, and clear assessment and evaluation system, and teaching time. Another promoting factor was research studies endorsed by government and more support on research studies by educational policy makers (National Research Council of the National Academes, 2011). In Thailand, successful implementation of STEM should draw participation from various sectors including government and private, community cooperation, and educational institutions putting hands together for research support and undertaking in order to develop STEM Education curriculum especially within the context of teacher development, education administration in school, etc.

CONCLUSION

Societies globally has currently undergone rapid change specifically communication technology that stimulates endless means of information transmission under the notion of science and technology information overflow which accelerate the advancement on socio-economic situation that affects commercial competition worldwide. It can be said that preparation population acquiring 21st century skills accommodate this aim on empowering capacity of young generations to live successfully in the changing society and become ready to encounter the future-to-come social, economic, and technological conditions. Active and ready for any change by building education superpower for quality population is one of development strategies of the country. Thailand education using integration strategies by promoting 4 subjects including science, technology, engineering, and mathematics or STEM Education is therefore the education approach preparing new generation of Thai population in the 21st century because the nature of 4 subjects promote learners knowledge and competence to live well with quality of life in the world of 21st century that change rapidly and follow globalization trend based on knowledge and advancement of technology. Moreover, STEM Education uplifts economy competitive advantage and empowers life quality development by exploiting interdisciplinary integration of all skills including knowledge, thinking skills, and other skills in problem-solving, researching, constructing, and developing many innovations in the world's today. STEM Education also focuses on in-depth concentration on interaction among students, information, and technology that allow flexibility in content, challenging, creative, novel, and meaningful problem-solving in the learning process. So, STEM Education is appropriate for modern generations of Thai learners to authentically learn and live their lives successfully in the future.

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