Agricultural-Based Stem Curriculum for Enhancing Youth Learning Skills in the 21st Century

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Abstracts

This research aimed to present the synthesis of meaning and components of youth learning skills in 21st century in agriculture-based STEM education and the development and efficiency validation of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century. This study was conducted through an exploratory sequential mixed method approach. The voluntary participants were comprised of 80 students from 10th and 12th grades. The qualitative data was analyzed by content and quantitative data was analyzed with percentage, mean, standard deviation, and t-test for one-sample statistics.

The results indicated that 1) the youth learning skills in 21st century in agriculture – based STEM education refer to a person who has STEM literacy, creative and innovation, acceptance of coding, collaborative problem solving, sustainability awareness, and entrepreneurial motivation which was at the highest appropriate level. 2) The agricultural-based STEM curriculum was developed with beyond the Thailand's Basic Education Curriculum (A.D. 2008 :1) at grade 10-12 to enhance youth learning skills in the 21st century included three learning units including the genetic engineering for delay ripening from ethylene, drone coding for precision agriculture, and my SMART farming for sustainable development. The quality of the developed curriculum was evaluated by the experts and obtained the good level. Moreover, the students' youth learning skills in the 21st century scores after the curriculum implementation were significantly different at 0.05 level above the cut-off score. The research findings revealed that the agricultural-based STEM curriculum was effective and could be used for promoting the youth learning skills in the 21st century.

Keywords: Agriculture-based STEM education; Youth; Learning skills in the 21st century,

Introduction

Thailand 4.0 was launched by the Thai government in 2016. This policy is expected to complement the wider 12th National Economic and Social Development Plan, for 2017–21, and fi t more broadly within the government's new 20-year National Strategy. Key parts of Thailand 4.0 emphasize security, wealth and sustainability. Thai government has set out three objectives for the 4.0 strategy: to elevate Thailand to the status of a high-income nation; to reduce inequality; and to promote environmentally sustainable growth and development. The progressively developing nation as Thailand, agriculture is one of the most important sources of income to the country. So, the Thailand 4.0 for agriculture, aims at increasing in average annual income of farmer by promoting and supporting with innovation, creativity, research and development, higher technologies and green technologies (Chingchit, S., 2017 : 6). Therefore, the education challenges to Thailand 4.0 were also pointed out for preparing Thai youth. This corresponded with who argued that one of the main factors for Thailand 4.0 achievement is

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education. There are quality education and education inequality challenges that require serious consideration.

The technological revolution that began in the last decades of the 20th century has affected nearly every aspect of life in the 21st century. In this way, the concept "Agritech" is a mix of the words Agriculture and Technology; and understanding the principle that every field or industry can be improved with innovative and digital thinking which required to encourage your kids to learn how to code. In addition, much of the problem solving work carried out in the world today is performed by teams in an increasingly global and computerized economy. The requirements for teaching and assessing collaborative problem solving skills are strongly driven by the need for students to prepare for careers that require abilities to work effectively in groups and to apply their problem solving skills in these social situations (OECD, 2013 : online). According to Battelle for Kids (2019), the P21 Framework is a unified, collective vision for learning that is known for describing the skills, knowledge, and expertise students must master to succeed in work and life in today's world and future; it is a blend of content knowledge, specific skills, expertise, and literacies. The framework, 21st century competencies are identified by three domains (a) life and career skills, (b) learning and innovation, and (c) information, media, and technology skills to prepare students for a more and more complex life and work environments in the 21st century.

One of effectively approach to prepare students for the future is STEM education which is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. According to the Thai and U.S. Department of Education, "All young people should be prepared to think deeply and to think well so that they have the chance to become the innovators, educators, researchers, and leaders who can solve the most pressing challenges facing our nation and our world, both today and tomorrow. But, right now, not enough of our youth have access to quality STEM learning opportunities and too few students see these disciplines as springboards for their careers(National Inventors Hall of Fame, 2021:9)."

Science, Technology, Engineering, and Mathematics (STEM) has become a government policy in many countries such as Thailand, United States (National Academy of Sciences, 2006:online; National Academy of Engineering, 2009:online; National Research Council , 2012:online). Australia, China, Korea, and Taiwan have been working to develop K-12 STEM curriculum designed as "integrative cross-disciplinary approaches within each of the STEM subjects" (Fan & Ritz, 2014, p. 8).

Because of the rapid growth in agriculture there has been an increased emphasis on providing students with an education that promotes their understanding of contemporary science concepts. There is a need to prepare future citizens to be able to deal with biotechnology, precision agriculture, SMART farming for sustainable, and the social, political, economic and ethical issues raised by its rapid development. Therefore, this study is intended to further validate an integrative STEM curriculum for upper secondary education which integrates inquiry-based science education with the use of the engineering gesign process and and coding-related activities.

Research Objectives

The purposes of this research were

1. to the synthesis and suitability evaluate of meaning and components of youth learning skills in 21st century for agriculture-based STEM education,

2. to development and efficiency validation of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century.

Research Methodology

A two-phased exploratory sequential mixed-methods was utilized by this research. The qualitative data were collected for meaning and components of youth learning skills in 21st century in agriculture-based STEM education in phase one to inform the collection of quantitative data in development and efficiency validation of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century of phase two. The research process is illustrated in Figure 1:

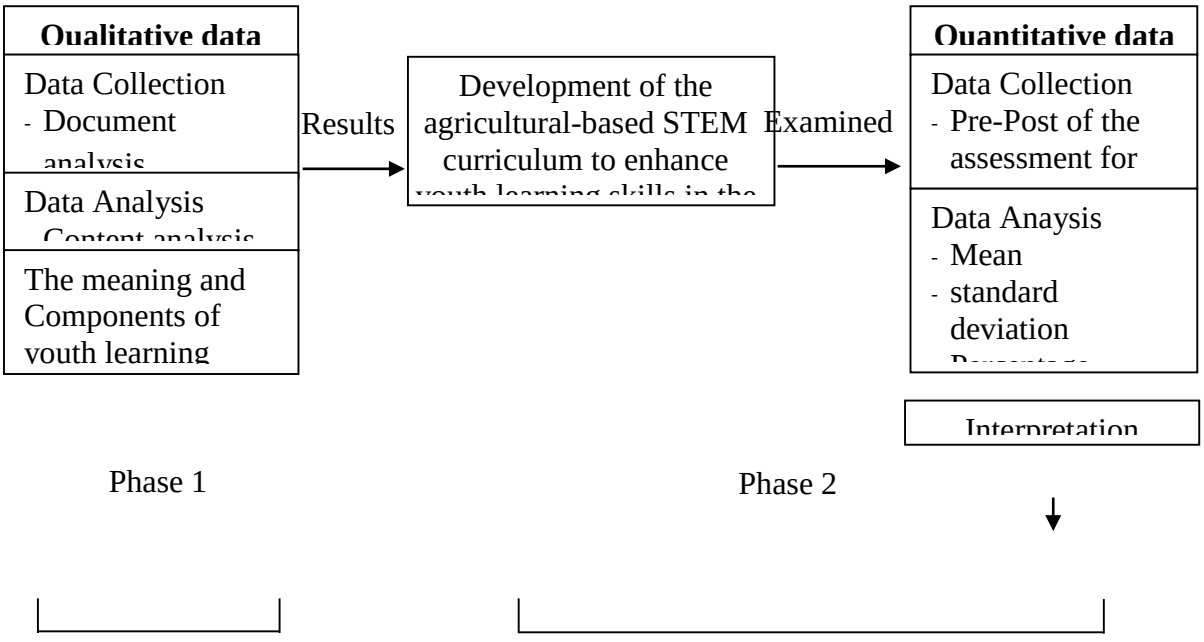

Figure 1: Exploratory sequential mixed methods design as applied in the research (adapted from Creswell & Plano Clark, 2018 : 9).

Phase 1: **The synthesis of meaning and components of youth learning skills in 21st century in agriculture-based STEM education**

Qualitative data was collected and analyzed in the first phase. The data was conducted by document analysis method and semi-structured interviews with 5 experts related youth learning skills in 21st century and agriculture-based STEM education. The data were analyzed by content analysis to synthesis of the meaning and components of youth learning skills in 21st century and agriculture-based STEM education which were evaluated by experts using a rating scale assessment.

Phase 2: The development of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century

The second phase, the qualitative findings were translated and used for development and efficiency validation of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century. The quantitative research methodology was applied in this study in the form of experimental research with a pre-experimental design as one group and a pretest-posttest design as the other. The research method was divided into two steps.

Step 1: The development and examination of the quality of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century are as follows:

1. Studying information about concepts, theories, the Thailand's Basic Education Curriculum (A.D. 2008 : 1) at grade 10-12, and research related to the development of curriculum development, learning skills in the 21st century, agriculture, STEM education.

2. Conducting the draft of agricultural-based STEM curriculum to enhance youth learning skills in the 21st century designed and created by synthesizing the elements of the curriculum development included principles, learning outcomes, learning activities: student guidebook, lesson plans: teacher guidebook, and assessment and evaluation.

3. Checking the quality of the draft of agricultural-based STEM curriculum to enhance youth learning skills in the 21st century by experts using a 5-level estimation scale.

4. Applying and testing the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century in a pilot trial with the upper-secondary students.

Step 2: Implementing the developed the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century are as follows:

1. Applying the developed agricultural-based STEM curriculum to enhance youth learning skills in the 21st century to a sample group of 80 students using one group pretest-posttest design with the assessment of youth learning skills in 21st century consist of rating scale and scoring rubric. The assessment was checked for the difficulty (0.20-0.80), the discrimination power (0.20-1.00), and the reliability of the Cronbach (0.2-1.00).

2. Determining the criteria using Berk's cut-off score method by comparing the sample group's pretest scores with the pilot trial group's posttest scores and analyzing the data.

Results

The results of phase 1: the synthesis of meaning and components of youth learning skills in 21st century in agriculture-based STEM education

After analysis of the related document and semi-structured interviews from experts, the meaning and components of youth learning skills in 21st century in agriculture-based STEM education was synthesized and evaluated of the suitability. The research results indicate the youth learning skills in 21st century in agriculture–based STEM education refer to a person who has STEM literacy, creative and innovation skills, acceptance of coding, sustainability awareness, and entrepreneurial motivation which were evaluated for suitability by experts assessment as shown in Table 1.

Table 1: The suitability of meaning and components of youth learning skills in 21st century in agriculture-based STEM education

Items	Average	Level of Suitability
STEM Literacy	4.80	Highest level
Acceptance of Coding	4.60	Highest level
Creative and Innovation	4.80	Highest level
Collaborative Problem Solving	4.60	Highest level
Sustainability Awareness	4.80	Highest level
Entrepreneurial Motivation	5.00	Highest level
Overall of the youth learning skills in 21st century	4.77	Highest level

From the table 1, the result showed that the meaning and all components of youth learning skills in 21st century in agriculture-based STEM education were suitability at highest level with the average of 4.77.

The results of phase 2: the development and efficiency validation of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century

Step 1: The development and examination of the quality of the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century

The information gained from the first phase and related documents were used to design a draft of agricultural-based STEM curriculum to enhance youth learning skills in the 21st century with beyond the Thailand's Basic Education Curriculum (A.D. 2008:1) at grade 10-12. The draft of curriculum consists of five components: principles, learning outcomes, learning activities: student guidebook, lesson plans: teacher guidebook, and assessment and evaluation. The cultivated banana and rice were selected as a real-life context of the curriculum. The instruction was applied by using six steps of the 6E learning by design (adapted from Burke, 2014 : 14-19) consist of engagement and elicitation, exploration, explanation, execution, enrich, and evaluation. The detail of draft of curriculum shown as Table 2

Table 2: The agriculture-based STEM education to enhance youth learning skills in the 21st century

Items	Hours
Teachers preparation for the curriculum implementation	3
Introduction of the agriculture-based STEM Curriculum /Pre-test	3
Learning unit 1: Genetic engineering for delay ripening from ethylene	8
Learning unit 2: Drone coding for precision agriculture	8
Learning unit 3: My SMART Farming with sustainable evelopment	8
Conclusion of agriculture-based STEM curriculum / Post-test	3
Teachers reflection of the curriculum implementation	3

The result of the draft of curriculum evaluation by the experts was that the curriculum has components which are appropriate and related to agricultural-based STEM contexts and that had a high level of quality. In Addition, the draft of curriculum was then piloted with 35 grade 10-12 students who were studying one upper-secondary school. The draft curriculum was revised by using the data gathered from the questionnaire of experts, the students' opinions toward the draft curriculum, the opinions of the participating teachers during the conversations and informal interviews as well as data obtained from the observations for the further improvement and ready for the implementation.

Step 2: Implementing the developed the agricultural-based STEM curriculum to enhance youth learning skills in the 21st century are as follows:

The revised curriculum of agricultural-based STEM curriculum was implemented for 80 students from 10th and 12th grades at one upper secondary school, Phitsanulok province, Thailand. The gathered data of students' learning skills in the 21st century in the curriculum implementation was were used for evaluation of the effectiveness of the revised curriculum by comparing post-test scores with a set criterion using cut-off scores using. It was found that the cut-off score was 75, calculated by selecting a score with the highest possibility of making a correct decision, the lowest possibility of making a mistake, and the highest accuracy coefficient of the criterion as a cut-off score. According to the comparison of the mean posttest youth learning skills in the 21st century scores with the cut-off score by a t-test one-sample, the results are shown in Table 3.

Table 3: The comparison of the students' youth learning skills in the 21st century mean posttest after curriculum implementation with the cut-off score

N	Mean	S. D	Cut-off score	*t*	*p*
80	79.38	4.56	75	17.97*	.00

Note: $* p < .05$.

From the table 3, the results represented that students' youth learning skills in the 21st century scores after studying the revised curriculum was significantly different at 0.05 level of significance above the cut-off score.

Discussion

From the results of phase 1, it showed that the meaning and all components of youth learning skills in 21st century in agriculture-based STEM education were suitability at highest level with the average of 4.77 was supported by the researcher not only analyzed the documents related to educational policy about STEM education, 21st century skills, the curriculum in national and international context but also interviewed and suitable evaluated the experts who related to STEM education, agriculture technology, science education, and mathematics education. The meaning and components of youth learning skills in 21st century in agriculture-based STEM education; STEM Literacy, acceptance of coding, creative and innovation, collaborative problem solving, sustainability awareness, entrepreneurial motivation; were syntheses to promote students' three main domains of learning; cognitive, psychomotor, and affective.

From the results of phase 2, the improvement of students' learning skills in the 21st century due to the agricultural-based STEM curriculum was supported by the followings: the curriculum was developed in a stepwise manner of the curriculum development process which consisted of the curriculum development model of Saylor, Alexander, and Lewis's (1991). This development started with identifying the desired results (goals) which considered what students should gain during the curriculum implementation. This was agreed with Wiggins G. and McTighe J. (1998), Tyler (1994), and Taba (1962) who argued that the curriculum development should begin with the ended or the desired results of the curriculum rather than to begin with text book, or favored lesson. The desired results leaded led to the worth selection of worthy topics, instructional materials, appropriated approaches, and suitable assessment. Moreover, the contents and activities in this curriculum were designed and developed based on consideration of the National Science Standards from IPST.

The agricultural-based STEM curriculum and its related instructional materials were developed by attempting to connect among students, their social world, and application of science, mathematics, technology, engineering to the students' world. This was in line with learning theories including cognitive constructivism, social constructivism, experience learning, and context-based learning. The real-life complex situation about agricultural development were used as a main vehicle to promote experiential and connected learning approaches to enhance students' understanding of their world and to engage students and provide them with opportunities to tackle real-world problems (Tytler et al.,2019).

The learning activities of this study were provided with the 6E learning by design (adapted from Burke, 2014 : 14-19) consisted of engagement and elicitation, exploration, explanation, execution, enrich, and evaluation. According to this approach, students had an opportunity to learn knowledge, apply their knowledge for dealing with the agricultural for sustainability development, and link it with their world which made student realize the benefits of learning in the curriculum and to gain meaningful learning. Combining inquiry-based learning with an integrated STEM approach provides rich opportunities for students to develop a range of general capabilities, such as critical thinking, self-direction, creativity, and communication (Rosicka, 2016). This finding was similar to the study of Tanaprayothsak W. (2005) which found that student achievement scores after using the science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach were higher than student achievement scores before using the curriculum. Furthermore, the inquiry focuses on a real-world problem that is meaningful to the students, their engagement has been found to extend beyond their immediate learning, to increased interest in further study in the component disciplines of STEM, and in future STEM related careers (Holmes, Gore, Smith, & Lloyd, 2018). The agricultural-based STEM curriculum which integrated, interdisciplinary approach to teaching science, technology, and mathematics including engineering-like design practices supports improved the learning skills in 21st century and increased learning-engagement.

Conclusion

In conclusion, it does not exaggerate to state that this the agricultural-based STEM curriculum can be applied in teaching and learning efficiently to enhance youth learning skills in the 21st century for preparing youth' STEM Literacy, creative and innovation, collaborative problem solving, acceptance of coding, sustainability awareness, and entrepreneurial motivation to deal with complexed situation of agriculture development in the future

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