Development of STEM Activities in Chemistry on "Protein"to Enhance 21st Century Learning Skills for Senior High School Students

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Abstract

This study aimed to develop STEM education activities on "Protein" for high school students and study efficiency of STEM activities for enhancing the 21st century skills including on learning and innovation skills in creativity,information media and technology skills and life and career skills of students. The evaluating result from the experts showed that developed STEM education activities was ranked in high score level. The STEM education activities efficiency E1/E2 was 85.65/89.52 that higher than the criteria of 80/80. The STEM activities was used by 42 students in grade 12 in the first semester of the academic year 2015 at Bodindecha (Sing Singhaseni) School. Sampling group was chosen using a purposive sampling approach. The results revealed thatafter students studied STEM activities, the academic achievement and the 21st century skillson learning and innovation skills in creativitywas significantly higher at .05 level, information media and technology skills of students were ranked in excellent level and life and career skills of students were ranked in very good level.

Keywords: 21st century skills; Chemistry; Protein; STEM activities; STEM education

Introduction

Nowadays, there are the global changes that effect the social, economic and political environment. Many countries prepare for 21st century especially USA. Americans concern about their present and future prospects in a time of economic, consequently they set up The Partnership for 21st Century Skills for infusing 21st century skills into education (Partnership for 21st century skills, 2008). The framework for 21st century learning consist of core subjects and three different skills including learning and innovation skills, information, media and technology skills and life and career skills (Partnership for 21st century skills, 2008). The skills and knowledge are not separate, but relevant (Education leadership, 2009), thus the 21st century skills play an important role in many countries of the world including Thailand. Many Thai organization are concerned about the education in 21st century, so they prepare a study to develop 21st century skills for children. The Institute for the Promotion of Teaching Science and Technology (IPST), and the Office of the Education Council, Thailand prepared children for living and working in 21st century through mastery learning, teach less, learn more and lifelong learning by the process of developing guidelines and policy directions from many countries, including the importance of integrating holistic approach. The education evaluation focused on educational goals, improving the classroom experience and the child center (The Office of the Education Council, 2014).

The developing of 21st century skills is necessary to manage learning process. The learning process that integrate many subjects together can response to the world changing in the 21st century and the STEM education is one of a field that enhances the 21st century skills (Siripathrachai, 2013). The STEM education is an interdisciplinary that integrates the four disciplines including Science, Technology, Engineering, and Mathematics through cohesive and active teaching and learning approaches that is coupled with real-world, problem-based learning (California Public Education, 2014). In Thailand, the Institute for the Promotion of Teaching Science and Technology is the main organization for STEM education. The STEM education is the

integration of knowledge and skills with a theme through activity based learning and project based learning that can improve student skills including technology and media skills, problem solving skills and communication skills (The Institute for the Promotion of Teaching Science and Technology, 2014). The skills are the 21st century skills that the students can apply to real world situation. Moreover, the 21st century skills will appear during the activities in the STEM process (Phattanachounchom, 2014).

The important thing to prepare the STEM activities is choosing a theme that relevant to the knowledge in the classroom. The learning process through STEM education can connect to the normal classroom period. It is not only merge to the subject, but also proper to the knowledge of learning process because the STEM education is promote the learning process through activities and projects that solve the real world problems for the experiences causing the creativity and innovation (Chanprasert, 2014). Furthermore, the main science course in Thailand (2008) from the office of the education council identify one of the efficiency of students that they should understand about biomolecules including protein, carbohydrate, lipid and nucleic acid. Protein is a kind of biomolecules that is one of a chemistry lesson for high school students and it can easily integrate with other subjects. Additionally, the chemistry lesson can approach to the real-world situation through the STEM education (Marle, 2014).

Due to the objectives of this paper, a researcher prepared the STEM activities with mini project in chemistry on "Protein" for high school students because the STEM education can combine into the classroom lesson through activity based learning and project based learning and link it to the real world situation. The researcher believe that the STEM activities can improve the 21st century skills of students.

Purpose of the Research

This study aimed to developSTEM activities on "Protein" for high school students and study academic achievement and the 21st century skillsincluding learning and innovation skills in creativity, information media

and technology skills and life and career skills of students after doing STEM education activities on "Protein".

Materials and Methods

Population and Sample

The population was grade 12 Students of Bodindecha (Sing Singhaseni) School, Bangkok, Thailand and sampling group was chosen using a purposive sampling approach. The sample was 42 students studying in grade 12 in science-mathmetics major of Bodindecha (Sing Singhaseni) School chosen by using a purposive sampling approach.

The STEM activities in chemistry on "Protein"

The research instruments for data collection is the STEM activities in Chemistry on "Protein" to enhance the 21st century skills for high school students. These were the main thing in the study. The STEM activities was an independent variable to enhance a dependent variable that consisted of academic achievement and the 21st century learning skills. The STEM activities was consist of the process of STEM education with protein topic. Moreover, all steps in the activities were integrated between science(S), technology(T), engineering(E) and mathematics(M). In this research, the researcher develop STEM activities by integrating science (S) in protein theme that is one of biomolecules in Chemistry with Mathematics (M) that is about cost and profit of the products from protein by using engineering process (E) through the activities to produce protein products and packaging of them. Moreover, in the activities also use technology (T) to search for the information about protein and use for presenting the products. Theactivities were arranged in an activity workbook for students that consisted of inquiry, activities, and project based learning. These also concluded the experimental and the knowledge. In this study, a teacher was a facilitator. The teacher got an instruction bookthat was important thing to guide about the activities. It was consist of the explanation for using the activity, a lesson plan, a way to answer questions in the activity and the answers of a test.

The STEM activities in chemistry on "Protein" was used for five

periods in Chemistry. Students in classroom were divided into the groups of 4-6 people by themselves. Each group got a STEM activities. They used the STEM activities to enhance both the 21st century skills and the knowledge of protein.

Period 1-2

The STEM activities in chemistry on "Protein" starting from a situation in a plastic factory. Students in any group with four to six people were briefed on a problem from the plastic factory. They played the role of the plastic factory's staffs. Each person in the groups had their own duties that created by the students for example a manager, a scientist, a creative, etc., but they also worked together in their factories. After the students had their own duties, they learnt about protein together in their groups following the STEM activities and a teacher was a facilitator. The knowledge that they should study was all about protein for example amino acids, peptide bonds, structure, protein denature, etc. that was shown in figure 1. In the STEM activities has information and questions about protein that the groups should answer. The groups could find the answers from the internet that is technology in STEM. Moreover, there were experimental about protein in the activities that each group should do together. The instruments of the experimental werepreprared by the teacher. The example of the experimental was shown in figure 2. In the final time of the period, the teacher and the students concluded about the knowledge of protein from the activities together. Finally, the teacher explained about an activity in the next period that every group should create their plastic product from milk in the next period.

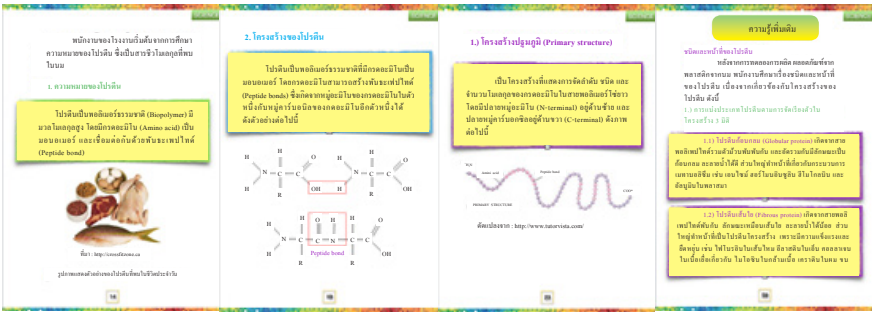


Figure 1 The example of protein knowledge in activities

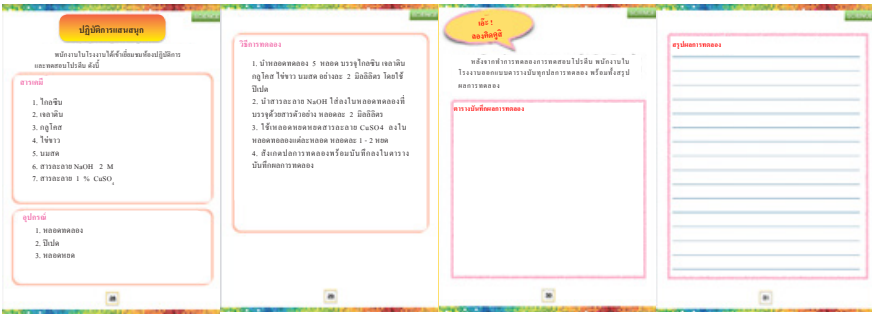


Figure 2 The example of an experimental activity

Period 3-4

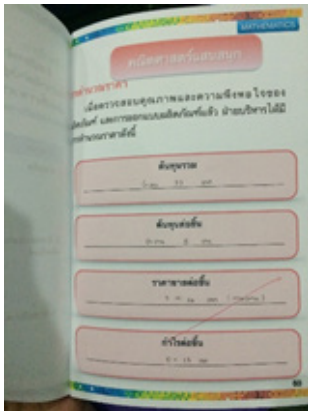
The students still played the roles of the plastic factory's staffs. The teacher set the instrument to demonstrate how to make plastic product from milk and discussed about protein denatured.After they saw the demonstration from teacher, they started to create their own products such as a magnetic, a decoration, dog's snack, etc. and wrote their plan in the STEM activity workbook that is an engineering process in STEM education. The plan consisted of creating the products, testing the product, creating the package of products, calculating cost and presenting the products. Furthermore, they also studied about protein through STEM process such as the process of making plastic from milk, the process of making the package of products, the process of calculating the cost of the products. Many processes used technology to done their works. In addition, the staffs should think how to test the quality of the product by themselves. They created their own ways to test the products by searching from the internet and the teacher was a facilitator. After they got the way to test the products, the students who acted as a creative created the package of the products by themselves with other students in the group helps and drew into the STEM activity workbook that shown in figure 3. Finally, they got all of the plan for their products. Moreover, every factory calculated a cost of the product for calculating capital and profit that was the integrating of Mathematics in STEM education. In the final time of the period, the teacher and the students concluded about the knowledge of protein and their plan

together. The examples of the plan from students wereshown in figure 4. Then the teacher explained about their homework project.

Homework project

Each factory should do the milk plastic together by adapted from the demonstration in classroom. They had 1 week for this project. They also tested the quality of the products following the plan from the activities. Moreover, they did the package of the products to cover their products. Moreover, every factory should create a product presentation by any kind of video and each factory would present the products in the next period. The important thing was the factories did all the process following their plan in the STEM activity workbook that created by themselves.

Figure 3 The example of packaging plan from students



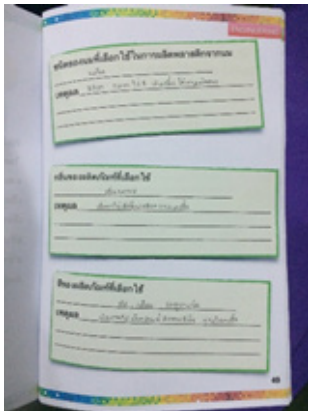


Figure 4 The example of the plan from students

Period 5

The teacher transformed the classroom into the exhibition for showing the products from the factories. Each factory presented their own products by using the video that shown in figure 5. Some factory made the advertising video and some factory set up the TV show videoto present their products. In this period, each factory presented their own products to other factories. The perfect products with packageswere shown in figure 6.Additionally, each factory wrote down advantages and disadvantages of their own factory and other factories for improving their own products. The teacher checked the products and the performance of the presentation, then gave them the points following a rubric score of the 21st century learning skills. Finally, the students and the teacher discussed about the exhibition and concluded together.

Figure 5 The video example that students created to present the products

Figure 6 The example of product with package by students

Measures

The measurement for data collection consist of:

The efficiency of STEMactivities on "Protein"

The STEM activities were the main instrument of the study. First, the researcher studied former researches to develop the activities. Then it was evaluated by IOC technique and the suitability of the STEM activity with a scale rate by the experts. Finally, the researcher adapted the activities following three experts advisesincluding science and education. The efficiency of the STEM activities was evaluated by E1/E2 (E1 wasa during-activity test score and E2 was a post-test score) finding from the try out group.

Academic achievement test

Pretest - Posttest on protein were used for this study. First, the researcher studied about the aims of studying protein from an instruction for teachers and a course details. The researcher created a protein test with four dimensions from Bloom's taxonomy that consist of remembering, understanding, applying and analyzing. The test is multiple choices that has four choices with one point if students chose a right choice and zero point if they went wrong. Second, the test was evaluated by experts from IOC technique. The researcher cut some items from the test out when the IOC was not reach a criteria. Third, the test was tried out by students who used to study protein before, but not the sample to find outdifficulty index (p) and discrimination index (r). Then chose the 20 items that reached a criteria ($p = 0.20\text{-}0.80$ and $r >= 0.2$) and the reliability (r_{tt}) of the test on protein was 0.84 that ranked in high score level.

The 21st century skills

The Learning and Innovation Skills in Creativity

Pretest - Posttest on creativity was used for this study. First, the researcher studied about the creativity that related to 21st century learning skills. The creativity skill is consist in learning and innovation skills that is one of the skills for 21st century. The researcher created a creativity test with two dimensions from Torrance and Guilford andchose originality and flexibility creativity.The creativity test is a subjective test that consist of

two situation questions including 4 items of originality creativity and other 4 items of flexibility creativity. The originality score was measured by Torrance theory and the flexibility score was measured by a scored that made from the number of different categories of relevant responses by the researcher. Second, the test was evaluated by experts from IOC technique. The researcher cut some items from the test out when the IOC was not reach a criteria. Third, the test was tried out by students who used to study protein before, but not the sample to find out the reliability (rtt) of the creativity test. The reliability was 0.717 that ranked in high score level.

The Information Media and Technology Skills

The authentic assessment for information media and technology skills was used for this study. First, the researcher created the authentic assessment for 21st information media and technology skills with rubric scores. Second, they were evaluated by experts from IOC technique. The researcher adapted some details following the expert's advises. The authentic assessment with rubric score of the skills was used to check the products from each factory including function, comfortable and price, how students found the information to answer the questions of protein in the STEM activities and the video that student developed for presenting their products.

The Life and Career Skills

The authentic assessment for life and career skills was used for this study. First, the researcher created the authentic assessment for life and career skills with rubric scores. Second, they were evaluated by experts from IOC technique. The researcher adapted some details following the expert's advises. The authentic assessment with rubric score of the skills was used to check about the presentation consisted of a pattern of the presentation, the communication skills, and the connection with audiences and check the group activity including the leadership and the responsibility.

Results and Discussion

After the process, the results were evaluated with statistical analysis methods.

The efficiency of STEM education activities on "Protein".

The activities was evaluated by the experts showed thatthe average of the activities was range between 3.00-4.67 and the standard deviation was range between 0.58-1.55. The efficiency of the STEM activities was try out from 23 students in grade 12 from Bodindecha (Sing Singhaseni) school. The result of the efficiency E1/E2 was 85.65/89.52 that higher than the criteria of 80/80 that was following the objectives because the process of developing the STEM activities was good. The researcher study about the STEM education, protein, activities and the 21st century learning skills carefully and adapted them together following the experts' advises. The researcher seriously concerned about the suitability of knowledge, the format of the activity, time, and language to attract the students.

The efficiency of students after using the STEM activities was separated in three ways. T-test analysis was used for achievement and creativity. The other 21st century learning skills assessed by rubric score that the researcher created following the experts advises.

The academic achievement test

One group pretest-posttest design was used for the study. The sample group was 42 students studying in grade 12 in science-mathmetics major of Bodindecha (Sing Singhaseni) School chosen by using a purposive sampling approach. The analysis of t-test was used for academic achievement on "protein".

Table 1 Comparison of academic achievement result on protein

	n	$\bar{x}$	S.D.	t	p	df
Pretest	42	3.07	1.702	13.928	0.000	41
Posttest	42	6.83	1.267			

$p > .05$

Table 1 shows that pre-test mean of academic achievement on protein was 3.07 out of 10 or 30.7% and standard deviation was 1.702. The mean of post-test was 6.83 or 68.3% and the standard deviation was 1.267. As it can be seen from the table, there was significant differences statistically in .05 levels between pre-test and post-test on protein because

STEM education in the STEM activities was integrated the knowledge of protein with technology, engineering and Mathematics together.The result was relevant to many researches. The integrated between science, technology and social made better score in the achievement of Chemistry (Jirasuksa, 2001) Moreover, the detail of protein in the STEM activities covered the scope of Thai science course in high school. The result also showed that the activity package can improve the academic achievement in Chemistry (Wittaya, 2012).

The 21st century skills

Learning and innovation skills in creativity

Table 2 Comparison of the 21st century learning skills on learning and innovation skills in creativity including originality and flexibility

Creativity		n	$\bar{x}$	S.D.	t	p	df
Originality	Pretest	42	4.19	4.533	7.618	0.000	41
	Posttest	42	10.67	3.310			
Flexibility	Pretest	42	1.83	1.480	6.683	0.000	41
	Posttest	42	3.43	0.590			

$p > .05$

Table 2 shows that pre-test mean on learning and innovation skills in originality and flexibility creativity were 4.19 out of 16 (26.19%) and 1.48 out of 4 (37%) and the standard deviation were 4.533 and 3.310 respectively. The mean of post-test on learning and innovation skills in originality and flexibility creativity were 10.67 (66.69%) and 3.43 (85.75%) and the standard deviation were 3.310 and 0.590 respectively. T-test were 7.618 and 6.683 on learning and innovation skills in originality and flexibility creativity respectively. As it can be seen from the table, there was significant differences statistically in .05 levels between pre-test and post-test on creativitybecause students studied the situations and the activities through the STEM activities following the instruction in the STEM activities and they tried to solve the problems, created the experimental and created their own products by themselves. The result was relevant to a former research. The STEM education learning improved

creative thinking of students (Benjakarn, 2015). As a result, the students got the learning and innovation skills on creativity including originality that the students created the different products from others and flexibility that the students can think several kind or different advantages of products. The comparing of the percentage score results between the pretest and posttest of achievement on protein and learning and innovation skills in creativity was shown in figure 7.

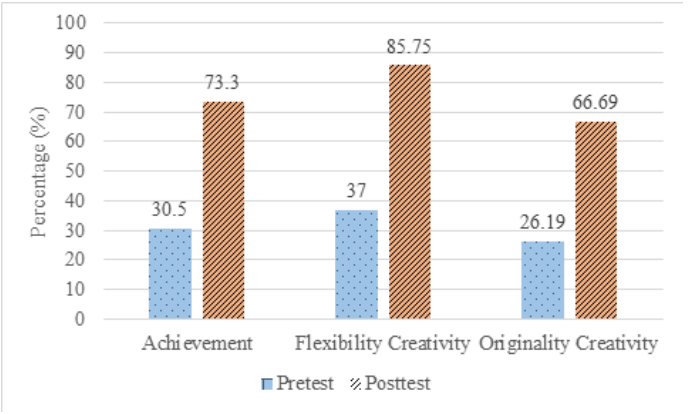


Figure 7 Comparing the percentage score results between the pretest and posttest of achievement on protein and learning and innovation skills in creativity

Information media and technology skills

Table 3 The Information media and technology skillsresult after using the STEM education activities on "Protein"

The 21st century learning skills	n	$\bar{x}$	Percentage	Range
Information media and technology skills	43	23.31	97.12	Excellent

90-100% Excellent, 80-89% Very good, 70-79% Good, 60-69% Fairy good, 50-59% Fair , <50% Fail

Table 3 illustrates that after the students used the STEM education activities on "Protein", they got 97.12% of information media and

technology skills that was ranked in excellent level.In addition, the skills were range inexcellent level because the students studied the situations and did many activities in the STEM activities. Moreover, they made their own products to be media for using in classroom and real-life situation. They alsoused technology to create their presentation of the productsby themselves for example; video presentation or power point program and used it to find out the knowledge in the activities. All of the reasons help students to get excellent level on information media and technology skills. The results also was relevant to many researches. The model of information and communication technology usage was appropriate and possible to enhance the 21st century learning skills (Oheeraphan, 2014) and the 21st century learning skills occurred during the project through STEM learning process with ICT (Phattanachounchom, 2014).

Life and career skills

Table 4 The Life and career skills result after using the STEM education activities on "Protein"

The 21st century learning skills	n	$\bar{x}$	Percentage	Range
Life and career skills	43	17.69	88.45	Very good

90-100% Excellent, 80-89% Very good, 70-79% Good, 60-69% Fairy good, 50-59% Fair , <50% Fail

Table 4 shows that after the students used the STEM education activities on "Protein", they got 88.45% of life and career skills that were range invery good level.In addition, the skills were range invery good level because the students did the activities and work together in the groups, so they discussed about their different opinion and shared their opinion together that help them to adapt in real-life situation. Moreover, the students had the opportunities to practice and present their productsin front of the classroomthat help them to get very good level in the skills. The results also was relevant to many researches. Practice-discussion-

modification cycle increase presentations grade and students are able to give presentations with confidence. (Suwa, 2012)

Conclusion

The STEM activities in chemistry on "Protein" enhancing 21st century skills for high school students results were conclude that the efficiency of the STEM activities in chemistry on "Protein" was 85.65/89.52 that higher than the criteria of 80/80. After the students used the STEM activities, the academic achievement of Chemistry on protein was significant differences statistically in .05 levels between pre-test and post-test. Moreover, the 21st century skills of students were developed includingthe learning and innovation skills on creativity of students was significant differences statistically in .05 levels between pre-test and post-test. In addition, the information media and technology skills was range in excellent leveland the life and career skills in was range invery good level.

Acknowledgements

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