Examine Students’ Perception on Their Critical Thinking and Problem-Solving Ability through Journal Writing for Learning about Genetics and DNA Technology

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Abstract. This study examined grade 12 students’ perception on their critical thinking and problem-solving ability when they participated in the STS genetics and DNA technology unit. The participants were 43 grade 12 students in Maung, Khon Kaen, Thailand. The STS genetics and DNA technology unit were provided learning activities through STS approach in framework of Yuenyong (2006) and has been taught by the first author for 3 weeks. Methodology regarded interpretive paradigm. Students’ perception on their critical thinking and problem-solving ability were interpreted through their reflection as journal writing for their learning about genetics and DNA technology. Students’ journal writing was collected after each class of the STS genetics and DNA technology unit was done. The findings revealed that students perceived on their critical thinking and problem-solving ability when they wrote their journals to reflect what they learned. These reflections provided 4 elements of critical thinking and problem-solving ability. These included reason effectively, used systems thinking, make judgment and decisions, and solve problem. These finding would be a good practices for teaching biology through STS approach to who may take further applications for science teaching and learning.

1. Introduction
The major corporations around the world found that the results of the study have defined the 21st-century skills that most valued in today's complex globalized and rapidly changing world are competencies or learning and innovation skills (4Cs) [7]. There are the basic skills that people in 21st-century must learn that allow them to become innovative in what they do. It would be mentioned that learning and innovation skills will prepared students for more complex life and work environments which is the necessary skills for developing students’ thinking both inside and outside the classroom. Learning and innovation skills composed of 4 critical skills included: creativity, critical thinking, communication, and collaboration that is essential for students in the future. This paper focuses on critical thinking and problem-solving ability that is the ability to identify, analyze and evaluate situations, ideas and information in order to formulate responses to problems.

According to the vision, there are some ways of developing scientific knowledge that could promoted students’ thinking through science, technology, and society that lead to various of students’ thinking. Therefore, the researcher believed that the thinking which develop on science classroom is critical thinking and problem-solving ability that involved to social issues in the present. The
researcher follows the framework of P21 [5] of critical thinking and problem solving ability in learning and innovation skills that composed of 4 elements:

- **Reason Effectively**
  - Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation.

- **Use Systems Thinking**
  - Analyse how parts of a whole interact with each other to produce overall outcomes in complex systems.

- **Make Judgments and Decisions**
  - Effectively analyze and evaluate evidence, arguments, claims and beliefs.
  - Analyze and evaluate major alternative points of view.
  - Synthesize and make connections between information and arguments.
  - Interpret information and draw conclusions based on the best analysis.
  - Reflect critically on learning experiences and processes.

- **Solve Problems**
  - Solve different kinds of non-familiar problems in both conventional and innovative ways.
  - Identify and ask significant questions that clarify various points of view and lead to better solutions.

These learning and innovation skills will examine students’ thinking that could be addressed by scientific knowledge related to science, technology, and society issue. In order to enhance teaching biology through STS approach. Yuenyong [9] stated that teaching science through STS developed many skills as well as thinking and decision-making skills, the perception of the relationship between science, technology, and society. Including knowledge, skills and the confidence to express opinions and take responsible action to address issues. Likewise, [6] studied Thai Students’ Decision Making in Societal Issue of Surface Area and Concentrated Solutions as a Factor in the Rate of Chemical Reactions found that STS approach could give students a chance to learn not only scientific knowledge but also developing the model of decision making. Moreover, Chantaranima and Yuenyong (2014) also reported that STS approach could support students to gain their capability of analytical thinking such as thinking for classifying, compare and contrast, reasoning, interpreting, collecting data and decision making. So, the researcher use STS approach of Yuenyong (2006) that consisted of five stages: (1) identification of social issues; (2) identification of potential solutions; (3) need for knowledge; (4) decision-making; and (5) socialization stage to enhance students’ critical thinking and problem-solving ability.

Some literature points suggested the investigation to examine students’ viewpoints or reflection on learning activity. [1] reported on Scientific Literacy of Grade 12 Student through Teaching and Learning about Genetics and DNA Technology on Science Technology and Society Approach Yuenyong (2006). The study revealed that after the class was done we should emphasize students to reflect their perspectives on journal writing because it can reflect the thoughts, feelings and knowledge of students which enable teachers to be used to adjust and develop appropriate learning activities in accordance with the interests and needs of students. Moreover, [4] stated that the overall majority of the students clearly stated potential benefits of journals writing as a learning tool. In addition to the satisfaction of students towards writing their own journals is consistent with their views on the benefits of writing. The journal writing is a summary of what is learned and helped developing writing skills and identifying problems and solutions [2]. In the same way, journal writing has been the case partly that the researcher try to add the ability that would be worthy for student’s learning and also as the reflection of endless learning process to teaching.

According to the literature of learning activities for biology in order to develop students to learn biology in science, technology, and society. The authors were suggested how to provide design learning activities to improve learning and innovation skills. The 4 elements of critical thinking and problem-solving will be taken into account for biology learning by self-directed learning and teamwork.
Therefore, the researcher has an objective to examine the critical thinking and problem-solving ability in learning and innovation skills on genetic and DNA technology unit though students’ journal writing by using scientific, technological and social instructional model of Yuenyong (2006).

2. Methodology
This study was a qualitative study focusing on paradigm in interpreting to search for examination grade 12 students’ critical thinking and problem-solving ability, during the first semester of 2018 school year, The Modindaeng Demonstration School of Khon Kaen University. The study would emphasize on the importance of the students’ critical thinking and problem-solving from reflecting’s learning in their journal writing for show their attitude and motivation toward science studying. Data were analyzed, interpreted, and concluded.

2.1. Participants
The participants were 43 grade 12 students in The Modindaeng Demonstration School of Khon Kaen University, Khon Kaen, Thailand.

2.2. Intervention
This research examined students’ critical thinking and problem-solving ability on genetics and DNA technology unit. The unit was taught by considers the relationship between science, technology and society (STS) approach of Yuenyong (2006). Consequently, the researcher was design learning activities that promote the critical thinking and problem-solving ability on GMOs issue on the table 1. Finally, students will show their different reflections on their journal writing after the class was done.

Table 1. Overview of the STS Genetic and DNA technology Unit. (a)

| Stages                        | Learning activities                                                                                                                                                                                                 |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identification of social issues stage | The issue of GMOs in Khon Kaen province was raised by news on “Let’s start to know what GMOs is ”headline. The news showed about the effects of GMO’ papayas. This news was expected to motivate students to identify some social issues from problem that they may involve with. |
| Identification of potential solutions stage | Students will need to identification of potential solution on identification of social issues stage from the question. - Students on each group brainstorm to review prior knowledge: “What knowledge can be used to solving the problem?” Moreover, Students create an unknown knowledge question and further research to find                                                                 |
| Need for knowledge stage      | The researcher use The 5Es Instructional Model on this stage. Engagement: Students watch video about GMOs on human’s life. Exploration: Teacher show the news “The effects of GMOs on agriculture in Thailand” and students brainstorm to answer the question on worksheet. Explanation: Teacher and student discussion to summarize “Should GMO products continue to be used?” Elaboration: Teachers present pictures on Power point and explain more GMOs. Evaluation: Teachers use the evaluation tools to be used either interview, observation or checklist etc. To evaluate the topic taught based on the learning objectives set at the beginning of the lesson. |
Table 1. Overview of the STS Genetic and DNA technology Unit. (b)

| Stages                | Learning activities                                                                                                                                 |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Decision-making stage | Each group works together to use critical thinking and problem-solving ability on GMOs. From Need for knowledge stage to create possible solution. Moreover, they work together again to make decision for select the best possible solution of group. Next, hand on design on worksheets and journal writing. |
| Socialization stage   | Each group presents “The best possible solution”. By record it is a Video File or post poster on Facebook. This performance will open for comments and ideas. Comments and ideas will be revise and develop again to completion. |

2.3. Data Collection and Data Analysis
For this study, the researcher follows the framework of P21 [5] of critical thinking and problem-solving ability to design the lesson plans through that composed of 4 elements: (1) reasoning effectively; (2) using systems thinking; (3) making judgments and decisions; and (4) solving problems. The genetic and DNA technology unit has been taught by the researcher for 3 weeks. The researcher was interpreted to examine what and how students’ critical thinking and problem-solving from students’ journal writing. Then, the interpretation will be rechecked as peer debriefing in order to show the credibility which the interpretation would depend on the particular researcher and each researcher.

3. Findings
The finding revealed that the learning activity about genetic and DNA technology unit promoted students’ critical thinking and problem-solving ability followed the framework of P21 [5] including: reasoning effectively, using systems thinking, making judgments and decisions, and solving problems. The journal writing could interpret through the critical thinking and problem-solving ability as follows:

3.1. The critical thinking and problem-solving ability from students’ journal writing
The students’ journal writing was reflected after the class of each plan was done. The examination from journal writing of students 43 members found that students’ journal writing organized into 2 groups are 1) students’ journal writing about contents of GMOs; 2) students’ journal writing which represent their critical thinking and problem-solving ability about GMOs. Consequently, the researcher focus on the results of examination students’ journal writing from 10 members (Table 2) that display students’ perception on their critical thinking and problem-solving ability in learning and innovation skills in group 2. This is an important data to analysis that students’ critical thinking and problem-solving ability on GMOs issue by using significant 4 features on figure 1.
Table 2. The critical thinking and problem-solving ability from students' journal writing. (a)

| Number of students | Reason effectively           | Use Systems Thinking | Make Judgments and Decisions | Solving Problems |
|--------------------|-------------------------------|----------------------|-------------------------------|------------------|
| 1                  | Student stated that genetic engineering lead to GMOs and GMOs are products which human needs such as genetic modification of papaya to increase agricultural productivity. | -                     | -                             | -                |
| 2                  | Student provided the reason that GMOs can protect plants from insects. Moreover, increasing crop products on agriculture. | Student related that GMOs help farmers increased their expenses such as insecticide. | Student compared between positive and negative ways of the effects of GMOs on economy and healthy. | Student suggested that we might get an effect from GMOs. So, we all have to determine the right solution that can solve by everyone. |
| 3                  | Student stated that the advantage is GMOs have the resistance to pest and disease. However, the dis-advantage is GMOs also give disease too. | Student stated that GMOs do not accept in aboard because they concern on the effect of GMOs. | Student thought that after the GMOs class, he more carefully on having meal. | -                |
| 4                  | -                             | -                     | Student reflected that GMOs are the issue for solving problem about mostly production of agriculture. | -                |
| 5                  | Student provided the causes that we needed GMOs because GMOs give more choices to us. | -                     | Student gave the advantage and dis advantage from GMOs. | -                |
| 6                  | Student gave the reason about GMOs that it answer many people for protect their plants from weeds. | -                     | -                             | -                |
Table 2. The critical thinking and problem-solving ability from students’ journal writing. (b)

| Number of students | Reason effectively | Use Systems Thinking | Make Judgments and Decisions | Solving Problems |
|--------------------|-------------------|----------------------|-----------------------------|------------------|
| 7                  | GMOs is the innovations from modification the organism to obey human in the present. | -                     | -                           | -                |
| 8                  | -                 | -                    | Student stated that GMOs is the new innovation for solving many problem on the other hands GMOs cannot be the solution but it is the problem. | -                |
| 9                  | -                 | -                    | Student reflected that GMOs have an advantage and disadvantage. The discovery of the way to solving the gap lead to solution of all problem from GMOs. | -                |
| 10                 | Student provided that GMOs solved the problem from pest but it might bring the concerning to consumers. | Student look that GMOs will give an effect from the residue to their health and environment. | -                           | -                |

Figure 1. Students’ critical thinking and problem-solving ability on journal writing.
This graph showed the data about the 4 elements which examine by interpreted from students’ journal writing from 10 of 43 students in class. The result found that the number of students’ reason effectively is 7, used systems thinking is 3, make judgment and decisions is 6, and solve problem is 1, respectively. It can be seen that the examination of journal writing on GMOs STS unit can enhance students’ critical thinking and problem-solving ability in learning and innovation skills.

4. Conclusion
The study examined students’ perception on their critical thinking and problem-solving ability in learning and innovation skills by journal writing which collected after the class. The learning activity was designed to develop high school students’ critical thinking and problem-solving ability which follows the framework of P21 Partnership for 21st century learning (2015) to learning biology. The focus had a relationship among science, technology, and society. This research also reported the process of developing Genetic and DNA technology unit on the STS approach [8]. The finding found that after learning through STS and interpreted from students’ journal writing. The number of students’ critical thinking and problem-solving ability are 10 members have critical thinking and problem-solving ability. These result show that students’ significant 4 features were 1) reasoning effectively: Students gave reasons for GMOs’ status in the present, and provided a variety of reasons why GMOs was happened; 2) using systems thinking: Students analyzed GMOs’ useful and useless on their health, and gave an implication of GMOs and the direct and indirect effects on environment; 3) making judgments and decisions: Students identified that GMOs is not the best solution for the basic human needs; and 4) solving problems: They reflected an individual’s viewpoint and motivation toward possible solution by together with everyone. Consequently, these reflection from journal writing involved with GMOs that promoted students’ perception on their critical thinking and problem-solving ability on genetic and DNA technology unit. It indicated that students also applied these results to their experience. Moreover, it could be mentioned that students could develop their ability of critical thinking and problem-solving while they learning STS of GMO issue.

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