Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education

Developing STS Projectile motion Unit for Providing Students' perception of the relationship between Science Technology Engineering and Mathematics

Prapatsorn SEATTHA, Jiraporn TUPSAI, Tawee SRANAMKHAM, & Chokchai YUENYONG*
Faculty of Education, Khon Kaen University, Thailand
*ychok@kku.ac.th

Abstract: STEM education suggested that students should be enhanced to learn science with integration between Science, Technology, Engineering and Mathematics. To help Thai students make sense of relationship between Science, Technology, Engineering and Mathematics, this paper presents learning activities of STS Projectile Motion Unit. The developing of STS Projectile Motion Unit is a part of research that aimed to enhance students' perception of the relationship between Science Technology Engineering and Mathematics. This paper will discuss how to develop Yuenyong (2006) STS Projectile Motion Unit. The Yuenyong (2006) STS approach provided learning activities in five stages. These included (1) identification of social issues, (2) identification of potential solutions, (3) need for knowledge, (4) decision-making, and (5) socialization stage. The learning activities could be highlighted as following. First stage, we use movie of 'Conan the barbarian (human catapult)'. Second stage, students will need to identification of potential solutions by Create Catapult Model. The need of scientific and other knowledge will be proposed for various alternative solutions. Third stage, students will gain their scientific knowledge through laboratory and simulation of projectile motion. Fourth stage, students have to make decision for the best solution of designing and creating catapult model based on their scientific knowledge and others (e.g. mathematics, economics, art, value, and so on). Finally, students will present and share their catapult model in society (e.g. social media or exhibition) in order to validate their ideas and redesigning.

Keywords: STEM, STS, Projectile motion, Technological Process, Engineering Process Design

1. Introduction

Lifelong learning is a prominent public policy theme for many countries and non-governmental organizations for education, economic, political, social and cultural purposes. Education systems are expected to convey values that will help develop more just and inclusive societies; they must also provide a variety of learning experiences to train a competent and active citizenship, and ensure quality and equity in learning outcomes. The goal and vision of the Thai science education suggests that science teaching and learning should lay emphasis on the relationship between science, technology and society; and life-long learning (IPST, 2002). And, the goal also aims to provide students with the intrigued study in Science, Technology, Engineering and Mathematics. So students can use the knowledge in many subjects to solve the problem, research and improve many things in today world. All learning from all teachers is help to solve real problems and very life problems. All those problems need all the knowledge you have, not individual one. (Bernard, 2012; Siripattrachai, 2013)

Introducing students to learn science regarding the integrated concepts of science, technology, engineering and mathematics is rising across the world (Bernard, 2012). According to 21st century citizen decision making, the issues are related to science, technology, engineering, and mathematics. Therefore, STEM Education was recognized. Science is the subject that study from natural phenomena

by scientific inquiry. Technology is the subject that applied all the subject to help solve the problems and also improving and developing to human need. Engineering is the subject that creative innovation and build many things to accommodate human by use the knowledge of Science, Mathematics and Technology to inventive. Mathematics is the subject that about calculation at this subject is very important foundation of education. Mathematics can be further in engineering. (Dejarnette, 2012; Bybee, 2010)

The literature suggested many possible activities of STEM Education. These included 1) Integrate Science, Technology, Engineering and Mathematics Content; 2) Link all the Science, 3) Mathematics and Technology to real world; 4) Engage in inquiry; 5) Project base; Apply Technology Strategically; 6) Focus on the skills of the Twenty first Century; 7) Building an awareness and participation in the community (Lungkhapin, 2013).

According to literature of activities for STEM Education, the authors were suggested how to provide the learning activities for physics in order to enhance students to learn physics on the relationship between science, technology, engineering, and mathematics. The 7 STEM guidelines activities (Integrate Science, Technology, Engineering and Mathematics Content; Link all the Science, Mathematics and Technology to real world; Engage in inquiry; Project base; Apply Technology Strategically; Focus on the skills of the Twenty first Century; Building an awareness and participation in the community) will be taken into account for physics leaning on the relationship between science, technology, engineering, and mathematics (STEM). It indicates that Science, Technology, and Society (STS) approach could support all these 7 STEM guidelines activities to provide physics learning activities on the relation between STEM.

The IPST has enhanced science teachers to teach science through engineering process design with aiming to provide STEM education in Thailand. They expected that scientific inquiry and designing for problem solving through engineering process design may allow students to integrate science technology engineering and mathematics for designing. This program has been launch since early year 2014 (IPST, 2014). The STS approach is another teaching approach that suggested science learning through technological or engineering process design (Soyjak, 2010). Therefore, the STS may provide student chance to learn science and creating some projects, volition, solutions with integration among science, technology, engineering and mathematics.

STS approach is learning that promotes inquiry scientific knowledge of social issues and technology in community, locality and world. (Yuenyong&Narjaikaew,2009; Chantaranima,2013) Therefore student will study the problem and also questioning on society and technology. Student is also self explanation by involvement of evidences in the communication, concept and reason and the way of comparison in the concept by strong of evidences before the determined of which way is important and not important of learning. It's also integrated in to other study. This is the way of STEM Education work. Beside that the student will do research the science knowledge from the objective in society and technology. Student also make good work and integrated all the knowledge to STEM Education.(Yuenyong, 2006; Klahan & Yuenyong, 2012.)

Beside the knowledge in the Science, Technology and Society also integrated in to other knowledge's that can be approved by the local expert. Also can letting student making project on open – ended problems by student own interest. This is the learning though the uses of real life and the local expert can be the guideline for student. Science, Technology and Society can help student with research, debate by listen to the expert. (Klahan & Yuenyong, 2012;Chantaranima, 2013)

2. STEM Educationand Engineering Design

The combination of the concept of Engineering Design and learning of Science, Technology and Mathematics is unique to STEM learning organization. As students are trying to learn, understand and practice skills in Science, Technology and Mathematics, they must have an opportunity to apply the knowledge gained to designing a product or a method to meet their daily life problem solving needs(IPST, 2013).

The Engineering Design Process (EDP) is about organizing ideas to improve decision making in order to develop high quality solutions and/or products to problems. The main ideas in successful instruction of the EDP are: students are engineers; teachers need to listen to students; and classroom environments need to change to properly enable learning through the EDP. Skills and abilities associated with engineering design for high school student consists of nine stages including: (1) The Identify need or problem (2) Research the need or problem (3) Develop possible solution(s) (4) Select

the Best Possible Solution (5) Construct a prototype (6) Test and Evaluate the Solution(s) (7) Communicate the Solution(s) (8) Redesign (9) Completion decision.(see Figure1)(Hynes et.al., 2011).

Throughout this process, students are constantly evaluating and testing their ideas, repeating steps as necessary and sometimes even restarting from the beginning. Occasionally the original idea will have some initial overlooked flaw or a different approach may become apparent through work on the challenge (Hynes et.al., 2011).

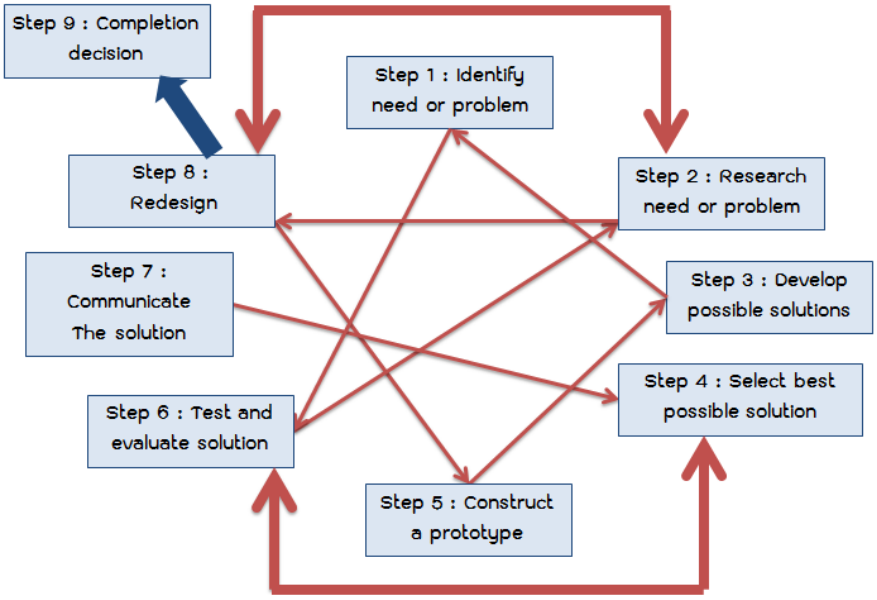


Figure 1: Engineering Design Process (Hynes et.al., 2011).

3. Science Technology and Society (STS) Approach and Yuenyong (2006) STS Projectile Motion Unit

According to the different and goals of STS there are several ways of attaining, objectives (Aikenhead, 1994). In this research, participants developed the STS unit regarding Yuenyong(2006)'s STS approach. Teaching and learning are started from society realm and moved to acquiring technology, science concepts and skills. Finally, students have chance to take action in society. Yuenyong (2006) developed science unit through STS approach that consisted of five stages including identification of social issues, identification of potential solutions, need for knowledge, decision-making, and socialization stage.

(1) **Identification of social issues stage.** This stage is designed to focus on student attention and attitudes also learning about Projectile motion. The STS instruction begins in the realm of society, social issue related to Projectile motion. These questions or problems of social issues need to be solved by citizens. For Projectile motion, the issue of the catapult motion and the social problem related Projectile motion should be brought into classroom by various strategies such as informing situation related these issues by posing on newspaper; posing the social questions related to for students to participate in public decision- making and seeing social problem by taking field trip.

(2) **Identification of potential solutions stage.** Students plan to solve the social problem related to Projectile motion. This stage supports students to concern with technological aspects for find the possible solutions. Technological aspects are skills to support student decision making. Students need to think of what, where, and how ideas, also design, systems, volition of application scientific knowledge work for that social problems. Teaching strategies may be used discussion among students' group, role-play brainstorming, searching information, via internet, and discussion with expert (e.g. engineers or scientists).

(3)**Need for knowledge stage.** This stage involves developing scientific knowledge. Social questions and technological knowledge can create science content. Projectile motion concept was formulated in many strategies to help students to understand the technology and social issues. The

strategies, included reflection reading document provided by teacher, and lecture. Students will gain the understanding about projectile motion concept and the short quiz will be taken after class at this stage.

(4) **Decision-making stage.** This stage with student involves in making a decision on how to use Projectile motion knowledge and technology. This aspect public rhetoric about Projectile motion related technological and social issues. It's becomes dominates like 'chances and problem', 'advantages and disadvantages', or uses and abuses'. Student will be given chance to learn and choose between alternatives in a thoughtful way systematically comparing as many relevant pro's and con's as possible. Teaching strategies may be used discussion among students' group, role-play, and brainstorming to allow students designing the possible solutions.

(5) **Socialization stage.** Students need to act as people who are a part of society by reporting their proposal for solving problem. Student might exhibit their solution in public by making poster, write newspaper article or science project(Klahan & Yuenyong, 2012).

Summary; an important learning activities based on the concept of Science, Technology and Society (STS) is help to improve students' learning behavior in self learning. Also, focus on problems in a present situation. The concept of Projectile motion in which the contents are related to the daily life learners. The physics learning about Projectile motion would allow students to learn physics on the relation between concepts of science, technology, engineering, and mathematics. Because human lives each day, are related to the phenomenon of movement and things all around. In the learning subject Projectile motion of physics, are three learning objectives including (1) can describe the phenomenon, (2) solve problems in daily life and (3) apply to subjects of Engineering, Technologies and Mathematics.

3.1 Developing STS Projectile motion Unit

Lesson plans, the concepts based on Projectile motion, Science, Technology and Society of Yuenyong (2006) with aiming to students to learn physics on the relation between concepts of science, technology, engineering, and mathematics. It is a step in creating and developing the following:

1. Study Principles, Goals, Visions, Standard measure and indicator. The Content and documents which are related to create a lesson plan follow science courses in the Basic of Education Core Curriculum 2008, in Projectile motion of ten grader students.

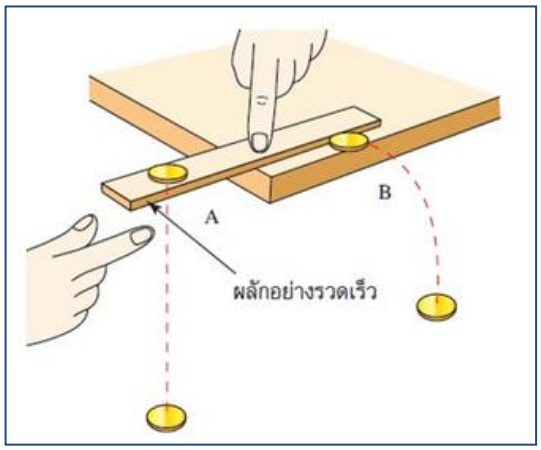
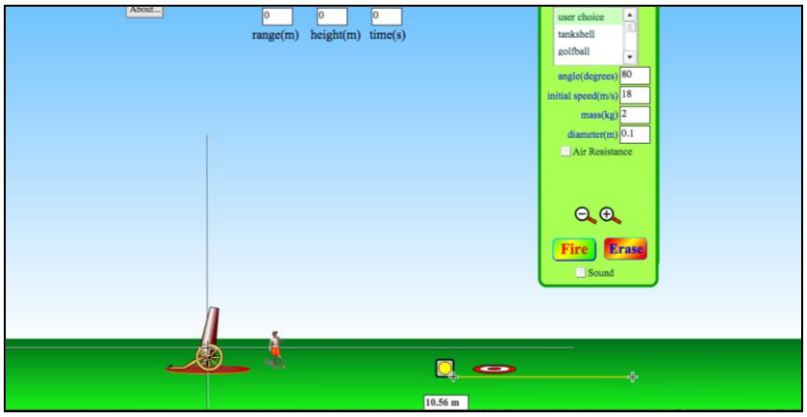
2. Create a Lesson plan on concept of Science, Technology and Society (STS) by using the STS approach of Yuenyong(2006).

- **-Identification of social issues stage:** on this stage, students must be aware of the social problems due to science and technology, and also grateful that he got involved to help solve the problem.
- **- Identification of potential solutions stage:** students will recognize social problems due to science and technology. At this stage, students will need to answer the problem on planning by the knowledge of their existence and planned to seek additional knowledge that will encourage students to find out the answer.
- **- Need for knowledge stage:** At this stage, students will need to study the scientific knowledge related to the problem.
- **- Decision-making stage:** on this stage, the students will use classroom knowledge to review the guidelines to solving and hand on the problem.
- **- Socialization stage:** Socialization stage, reflected in the students review of concept and valid through social process. At this stage, students will present a scientific exhibition project or campaign.

3. Present the Thesis to advisors.
4. Improve Lesson plans based on the guidance of advisors.
5. Recreated lesson plan, also present the experts for revision.
6. Improve lesson plan based on the recommendations of the experts.
7. Lesson plan use with students who are not the target group.
8. Implement adjust lesson plan for further improving.
9. Implement Lesson plan adjusted to the target group students.

Table 1: Learning management plan of Yuenyong (2006) STS *Projectile motion* Unit

Stage	Activity
Identification of social issues stage.	Students watched movie about "Conan the Barbarian(Human catapult)"It is a social issue which relationship with Projectile Motion. This movie, Catapult will be used to shoot objects to a destination in the Projectile Motion.  **Figure 2**Conan the Barbarian(Human catapult) Questions for Students: 1. In Movie, how does Catapult shoot? 2. If students will create Catapult, how do you create? Teacher will set the activity, and let the student solve this problem on paper. Student will design and create Catapult by used scientific knowledge in Projectile motion.
Identification of potential solutions stage.	Students will need to identification of potential solutions on identification of social issues stage **"Create Catapult"** First, Students will create questions on knowledge **"Create Catapult"** Then each group brainstorm together to review prior knowledge:"What knowledge can be used to solving the problem?".Moreover, Students create an unknown knowledge question and further research.
Need for knowledge stage.	Teacher set exploration activity and explanations to application for **"Create Catapult"** by **Activity 1: Coins' Fall Demonstration.** Teachers demonstrate a Coins' Fall to study about Coin A's motion and Coin B's motion when it was pushed to the ground. For demonstration, teachers set Ruler, Coin A and Coin B follow figure 3. Next, teachers' right hand press center of ruler and teachers' left hand fast push ruler (see figure 2). Teacher and Students observe and discuss together about "What will happen when teacher fast push ruler?"which is related with **Motion in Gravity Field and Projectile Motion.** Moreover, teachers explain knowledge about **Projectile Motion.** The purpose of this demonstration is 1) to study the projectile motion of object. 2) To study relationship between the Motion in Gravity Field and Projectile Motion. And 3) this demonstration is basic for Projectile motion learning to "Create Catapult".

Stage	Activity
	 **Figure 3**Coins' Fall **Activity 2: Class Discussion I** After students learned in Activity 1. Next step, They will be Class Discussion about projectile motion as flat and horizontal axis, displacement and velocity for each position of projectile motion, and net of velocity in projectile motion. Teacher, then, try to enhance student to apply these knowledge for creating catapult that was raised in the identification of social issues stage. **Activity 3: Projectile Simulation Lab** The purpose of this Lab is 1) to study Velocity and Angle of object in the projectile motion.2) Apply knowledge to create Catapult. **First Step,** Teacher asks the following questions in order to engage students to identify the problem of projectile motion experimentation in simulation lab. 1) If you shoot object in projectile motion which have difference of initial velocity, how will displacement change? 2) If you shoot the object in projectile motion which has the same initial velocity but difference of angle of motion, how will displacement change? **Second Step,** students start to do simulation lab to find solutions of problems of projectile motion. The simulation lab was provided as shown in figure 3.  **Figure 3** Example Program Projectile Simulation Lab

Stage	Activity
	Activity 4:Class Discussion II After students learned about Projectile Simulation Lab. Next step, They will discuss about how to explain the projectile motion from the initial to the end of motion at the flat axis. Teacher may enhance students to apply this knowledge for finding some solutions of the problem of creating catapult that was raised in the first stage of Yuenyong (2006) STS – identification of social issues stage. **Activity 5: Mathematical Calculations Problem Solving** Teacher provides activity of calculation about projectile motion. These include: • Exercise about net total of velocity and Instantaneous velocity in projectile motion • Calculation of net total of velocity and Instantaneous velocity in bullet motion when it travels as projectile motion from the Catapult.
Decision-making stage.	Each group work together to make decision on how to use knowledge of Science and Mathematics (Calculation). From Need for knowledge stage to create possible solution(s).Moreover, they work together again to make decision for select the Best Possible Solution. Next, hand on "Create Catapult" by on paper sheets.
Socialization stage.	Each group presents a"How to Create Catapult by step by step". By record it is a Video File and share it on facebook. This video will open for comments and ideas. Comments and Ideas will be revised and developed again to completion.

3.2 STS Projectile motion Unit and guideline of relationship between Science Technology Engineering and Mathematics.

How the STS Projectile motion unit provides students to learn physics on the relationship between Science, Technology, Engineering and Mathematics will be explained. Provided activities in each stage of STS Yuenyong (2006) will be clarified to show possible students learning about concepts of Science and Mathematics and process of technology and Engineering design.

From each stage of STS Yuenyong (2006), Students will use combination of the concept of Engineering Design, Technology (Problem solving) and learning of Science(Projectile motion) and Mathematics. As students are trying to learn, understand and practice skills in Science (Projectile motion)and Calculation in Mathematics, they must have an opportunity to apply the knowledge gained to designing and create a Catapult which are product or a method to meet their daily life problem solving needs through Engineering Design process(IPST, 2013) that consists of nine stages including: (1) The Identify need or problem (2) Research the need or problem (3) Develop possible solution(s) (4) Select the Best Possible Solution (5) Construct a prototype (6) Test and Evaluate the Solution(s) (7) Communicate the Solution(s) (8) Redesign (9) Completion decision.(see Figure 1)(Hynes et.al., 2011).

First, learning of Projectile motion through Yuenyong (2006) Science Technology and Society (STS) began with Identification of social issues stage. The Social issue was raised by the movie of "Conan the Barbarian(Human catapult)".This social issue, teacher set activity to Students will designing and create a Catapult by used scientific knowledge of Projectile motion. In this stage, students will identify problems which has consistent with "Engineering Design Process" on step one: the Identify need or problem.

Second, Identification of potential solutions stage, students will create questions on knowledge how use "Create a Catapult". Next step, each group brainstorm together to review prior knowledge: "What knowledge can be used to solving problem?".Moreover, Students create question to unknown knowledges and need further research.

Third, Need for knowledge stage, students study knowledge of science and mathematics(calculation) involving "Create a Catapult"on a learning resources such as books, magazines, and an internet. Furthermore, Teacher set exploration activity and explanations to apply for"Create a Catapult".

Activity 1: Coins' Fall Demonstration.

Activity 2:Class DiscussionI

Activity 3: Projectile Simulation Lab

Activity 4: Class Discussion II

Activity 5: Mathematical Calculations Problem Solving

Identification of potential solutions stage and Need for knowledge stage have relate with knowledge of Science(Projectile motion) and Mathematics(calculation).Moreover, both stage have relate with "Engineering Design Process" on step two: research the need or problem.

Fourth Decision-making stage, each group work together in making a decision on how to use knowledge of Science and Mathematics(calculation) from Need for knowledge stage and create possible solution(s).Moreover, they work together making decision for best possible solution. Next, hand on design Safety Road on paper sheets.

Found that "Decision-making stage" has relate with knowledge of Science (Projectile motion), Mathematics (calculation) and Technology.

Moreover, this stage as relate with "Engineering design" on step 3-5:

- Step three: Develop possible solution(s), each group apply knowledge from Need for knowledge stage to create possible solution(s).
- Step four: Select the Best Possible Solution. This step, each group work together in making a decision on select the best possible solution for "Create a Catapult".
- Step five: Construct a prototype. After select the best possible solution, each group start"Create a Catapult"on paper sheets.

Fifth, Socialization stage, This stage, Students need to act as people who are a part of society by reporting their solving problem proposal (Klahan & Yuenyong, 2012). Student will exhibit their solution in public that "How to Create a Catapult step by step". By record it is a Video File and share on Facebook. This video will open for comments and ideas. Comments and Ideas will be revise and develop again to completion.

Found that, this stage as relate with "Engineering design" on step 6-7

- Step six: Test and Evaluate the Solution(s). Students test a Catapult to fin
- Step seven: Communicate the Solution(s). There is a video for share comments and ideas.
- Step eight: Redesign. Comments and ideas will be revise and develop again to completion for "Create a Catapult".

4. Conclusion

Development of the Yuenyong (2006) STS projectile motion learning unit probably give students chance to learn physics with integration knowledge of science, technology, engineering, and mathematics. Based on the activities of this unit seems to be provided students chance of interaction in the relationship of Science, Technology, Engineering and Mathematics into 2 groups. First, the unit provided activities for developing skills, abilities and knowledge such as projectile motion (scientific knowledge) and mathematics as a tool of physics explanation and observation. Second, the unit provided activities for creating some process or designing such as technological process and engineering process design. This instructional design show that the five stages of Yuenyong (2006) STS allow teachers to organize the activities as scientific inquiry with engineering process design when students try to find possible solutions of the social issues and then make decision to do their best solution.

Acknowledgements

The research was financially supported by the institute for the promotion of teaching science and technology (IPST) and the project for the Promotion of Science and Mathematics Talented Teachers (PSMT)

References

Aikenhead, G. (1994a). What is STS science teaching? In Solomon, J. and Aikenhead, G. (Eds.). (pp.169 186). *STS Education : International Perspective on Reform*. New York, USA: Teachers College Press, Columbia University.

Bernard J. Sadusky. (2012(. STEM standards of practice and STEM education definition. Retrieved from www.marylandpublicschools.org/NR/rdonlyres/3ECF0379-2EE9-42AD-A5FC-CA81E8F3FEEA/32260/MarylandStateSTEMStandardsofPractice_.pdf

Bybee, R.W.(2010). Advancing STEM education : A 2020 vision. *Technology and Engineering Teacher*.70(1), 30-35.

Chantaranima, T. (2013). The Outcomes of Teaching and Learning About Sound Based on Science Technology and Society (STS) Approach. *Procedia - Social and Behavioral Sciences.* 116 (2014), 2286 – 2292.

De Jarnette, N. K. (2012). America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives.*Education*, *133*(1), 77-84.

Hynes, M., Portsmore, M., Dare, E., Milto, E., Rogers, C., Hammer, D. et al. (2011). Infusing Engineering Design into High School STEM Courses. *National Center for Engineering and Technology Education*,(165), 8-13.

Institute for the Promotion of Teaching Science and Technology (IPST). (2013) .*What is STEM Education.* Bangkok: Institute for the Promotion of Teaching Science and Technology.

Institute for the Promotion of Teaching Science and Technology (IPST). (2014). *STEM EDUCATION THAILAND*. Retrieved March 10, 2015, from: http://www.stemedthailand.org/

JL Stanbrough. (2007). Physics Lab : Centripetal Force and Speed. Retrieved from http://www.batesville.k12.in.us/physics/phynet/mechanics/circular%20motion/labs/cf_and_speed.htm

Klahan, T. & Yuenyong, C. (2012). An analysis of grade 12 students' technological capability in learning about electromagnetics through science technology and society approach (STS approach). *Procedia - Social and Behavioral Sciences.* 46 (2012), 5085 – 5093.

Lungkhapin S. (2013). Guidelines and principles of STEM education. Retrieved from www.thailand.intel.com/content/www/th/th/education/intel-in-education.html

Siripattrachai, P. (2013). STEM education and 21th century skills development.*Executive journal*, 33(2), 49-56.

Soyjak, T. (2010). *Students' capability of analyzing the philosophy of sufficiency economy resulting from learning about Newton's of motion through Yuenyong (2006) Science Technology and Society (STS) approach infusion with the philosophy of sufficiency economy*. Master of Education Thesis in Science Education, Graduate School, KhonKaen University.

Williams, P.J. (2011). STEM Education: Proceed with Caution. *Design and Technology Education: An International Journal*, 16(1), 26-35

Yuenyong, C.: 2006. *Teaching and Learning about Energy : Using STS approach*. Bangkok, Thailand : Thesis of Doctoral Degree in Science Education, Kasetsart University.

Yuenyong, C. &Narjaikaew, P. (2009). Scientific Literacy and Thailand Science Education. *International Journal of Environmental and Science Education*. 4(3): 335-349.