Design steps toy car for STEM to STEAM Education learning in Chiang Mai Rajabhat Demonstration School

Kritsada Boonchom
Department of Physics and General science, Faculty of Science and Technology, Chiang Mai Rajabhat University, Chiang Mai 50300, Thailand
Email: kritsada_boo@cmru.ac.th

Abstract. The objectives of this study were designing a set of “Toy car” learning activity on the basis of STEM education and improved set of STEM activity. Development of a set of STEM activities was executed according to the engineering process. From the experiment and studied relate theory, the results were manual for teaching and student activity training. It was analysed Index of Objective Congruence (IOC) results found that STEM learning activity package was correct in content, learning activities and suitable for the purpose. The activity was tested by used to learning management with grade 5 and 6’s students in CMRU demonstration school. It found that the students’ satisfaction level toward STEM process was at a “good” level. It has value of $4.11 \pm 0.71$. The STEM activity was improving to STEAM.

It was presented in teacher training and found that the participants’ satisfaction level toward STEAM process was at a “good” level. It has value of $3.98 \pm 0.54$. Participants, 89.60% were confident that arts can be integral with science mathematics and this activity can be used to improve 21st century learning skills.

1. Introduction

STEM education is a teaching approach that integrates knowledge in 4 disciplines including science, engineering, technology and mathematics. [1] It was published by the Institute for the Promotion of Teaching Science and Technology (IPST). This teaching approach is to create understanding of the subject matter in the course through real practice, coupled with the development of thinking skills, questioning, solving problems and finding information and analyzing new findings and able to apply those findings to improve productivity apply to solve everyday problems. [3], [9] STEM education learning in Thailand by IPST consists of 5 characteristics including:
1) Focuses on integrating into every course 2) Apply 4 subjects to daily life and career 3) Focus on developing skills in the 21st century 4) Challenge students’ ideas 5) Open to students to show reviews and understanding with the 4 subjects [3], [12], [13], [14]. Chiang Mai Rajabhat Demonstration School has aims to be developing innovation teaching that can develop learners to have learning skills in the 21st century. Lalida Umbua from IPST presented STEM education can enhance the abilities of students at every level of learning by developed 21st century skill lead to promote their abilities to become quality manpower in the future. [10] Watputtabucha School used STEM techniques in topic was how to plant rice to improve students’ skills. (4C) Students must learn and work in group. [6]

Thus, STEM education was received interesting from school into developing. And, the development issues must be related to science, mathematics, technology at the elementary level. Therefore, the researcher determines the issues in the energy topic that is related to mechanical energy, friction, movement, measuring and the use of tools leads to the design of STEM “Toy car” learning. Researcher was interested in this topic due to the activity “Win One Day” in the physics class of STUST. [7]
The objectives of this study were designing a set of “Toy car” learning activity on the basis of STEM education and improved set of STEM activity.

2. Research methodology

Development of a set of STEM educational activities, it is executed according to the engineering process shown in the diagram as follows:

![Engineering process of “Toy car” learning activities](image)

Figure 1 Engineering process of “Toy car” learning activities

3. Results and Discussion

Determine the content scope at the primary level that relate to the core curriculum of basic education (A.D.2008), [5] In this case, the energy was selected. How was STEM linked to the subject matter of learning? The linked was shown in the diagram as follows:

| Science | Engineering Content learning: Engineering process |
|---------|--------------------------------------------------|
| Strand 4: Forces and Motion | Technology Strand 1: Living and Family |
| Standard SC4.2: Understanding of the characteristics and various types of motion of natural objects; having investigative process for seeking knowledge and scientific reasoning; transferring and putting the knowledge into practice | Standard OT1.1: Understanding of the concept of work; possessing creativity and skills in various respects-work processes, management, problem-solving, teamwork and investigation for seeking knowledge, morality, diligence, and awareness of the need to economise on the consumption of energy, resources and the environment for living and for family |
| Strand 5: Energy | Strand 2: Design and Technology |
| Standard SC5.1: Understanding of the relationship between energy and living; the energy transformation; the interrelationship between substances and energy; the effects of energy utilization on life and the environment; having investigative process for seeking knowledge; transferring and putting the knowledge into practice | Standard OT2.1: Understanding of the technology and technological processes; designing and making objects, utensils or the methodologies through the creative technological processes; selective utilization of the technologies beneficial to one’s life, society and the environment; participation in sustainable technological management |
| Strand 1 Number and Operation | Strand 3: Information and Communication Technology |
| Standard MA1.1: Understanding of diverse methods of presenting numbers and their application for real life | Standard OT3.1: Understanding, appreciation and efficient, effective and ethical application of information technology in searching for data, communicating, problem-solving, working and livelihood |
| Standard MA1.2: Understanding of the results of operations of numbers, the relationships of operations, and the application of operations for problem-solving | Strand 2: Measurement |
| Standard MA2.1: Understanding of the basics of measurement; ability to measure and to estimate the size of objects | Standard MA2.2: Solving measurement problems |
| Strand 2: Measurement |

| Mathematics | |
|-------------|--------------------------------------------------|
| Strand 1 Number and Operation | Technology Strand 1: Living and Family |
| Standard MA1.1: Understanding of diverse methods of presenting numbers and their application for real life | Standard OT1.1: Understanding of the concept of work; possessing creativity and skills in various respects-work processes, management, problem-solving, teamwork and investigation for seeking knowledge, morality, diligence, and awareness of the need to economise on the consumption of energy, resources and the environment for living and for family |
| Standard MA1.2: Understanding of the results of operations of numbers, the relationships of operations, and the application of operations for problem-solving | Strand 2: Design and Technology |
| Standard MA2.1: Understanding of the basics of measurement; ability to measure and to estimate the size of objects | Standard OT2.1: Understanding of the technology and technological processes; designing and making objects, utensils or the methodologies through the creative technological processes; selective utilization of the technologies beneficial to one’s life, society and the environment; participation in sustainable technological management |
| Standard MA2.2: Solving measurement problems | Strand 3: Information and Communication Technology |
| Strand 1 Number and Operation |

| Strand 1 Number and Operation | Technology Strand 1: Living and Family |
| Standard MA1.1: Understanding of diverse methods of presenting numbers and their application for real life | Standard OT1.1: Understanding of the concept of work; possessing creativity and skills in various respects-work processes, management, problem-solving, teamwork and investigation for seeking knowledge, morality, diligence, and awareness of the need to economise on the consumption of energy, resources and the environment for living and for family |
| Standard MA1.2: Understanding of the results of operations of numbers, the relationships of operations, and the application of operations for problem-solving | Strand 2: Design and Technology |
| Standard MA2.1: Understanding of the basics of measurement; ability to measure and to estimate the size of objects | Standard OT2.1: Understanding of the technology and technological processes; designing and making objects, utensils or the methodologies through the creative technological processes; selective utilization of the technologies beneficial to one’s life, society and the environment; participation in sustainable technological management |
| Standard MA2.2: Solving measurement problems | Strand 3: Information and Communication Technology |
| Strand 1 Number and Operation | Technology Strand 1: Living and Family |
| Standard MA1.1: Understanding of diverse methods of presenting numbers and their application for real life | Standard OT1.1: Understanding of the concept of work; possessing creativity and skills in various respects-work processes, management, problem-solving, teamwork and investigation for seeking knowledge, morality, diligence, and awareness of the need to economise on the consumption of energy, resources and the environment for living and for family |
| Standard MA1.2: Understanding of the results of operations of numbers, the relationships of operations, and the application of operations for problem-solving | Strand 2: Design and Technology |
| Standard MA2.1: Understanding of the basics of measurement; ability to measure and to estimate the size of objects | Standard OT2.1: Understanding of the technology and technological processes; designing and making objects, utensils or the methodologies through the creative technological processes; selective utilization of the technologies beneficial to one’s life, society and the environment; participation in sustainable technological management |
| Standard MA2.2: Solving measurement problems | Strand 3: Information and Communication Technology |
Next, the researcher studied various variables involved in creating activity sets and analysed Index of Objective Congruence: IOC. The results as showed in table 1.

| Mass of Toy car (g) | Inclination angle (Degree) | 15 | 20 | 30 | 45 |
|---------------------|-----------------------------|----|----|----|----|
| 37.03               | Distance (m)                | 2.35 | 3.04 | 3.89 | 4.22 |
|                     | Kinetic energy (J)          | 0.056 | 0.074 | 0.109 | 0.154 |
| 47.27               | Distance (m)                | 2.76 | 3.14 | 4.05 | 4.41 |
|                     | Kinetic energy (J)          | 0.069 | 0.091 | 0.133 | 0.188 |
| 57.29               | Distance (m)                | 2.87 | 3.57 | 4.60 | 5.28 |
|                     | Kinetic energy (J)          | 0.087 | 0.115 | 0.168 | 0.238 |
| 85.04               | Distance (m)                | 3.01 | 3.86 | 4.97 | 5.82 |
|                     | Kinetic energy (J)          | 0.129 | 0.171 | 0.250 | 0.354 |

From table 1, the distance that toy car can drive increases with the inclination angle of floor increasing. When the angle of inclination increases, the height at the beginning will be higher. If considering the relevant variables, work force and energy According to 2nd Newton’s law, the car will move to the ground tilted by force \( \vec{F} \) shown in Eq. 1. \([11]\)

\[
\vec{F} = m\ddot{a} = mg \sin \theta
\]

The gravitational potential energy \( (E_p) \) will increase shown in Eq. 2

\[
W = \int \vec{F} \cdot d\vec{S} = mg \sin \theta (L) = mg L \sin \theta = mgh = E_p
\]

According to energy conservation law, toy car will have more kinetic energy and will be able to run more distances.

![Figure 2 The movement of toy car](image)

At P.2, the potential energy is transformed into kinetic energy, which is the energy associated with the movement.

\[
W = \int \vec{F} \cdot d\vec{S} = \int m \frac{dv}{dt} \cdot d\vec{S} = m \int v dv = \frac{1}{2} mv^2
\]
After that, the car moved and stops at P.3. Finally, the kinetic energy will transform into work due to friction shown in Eq.(4) to (7).

\[ W = \int \vec{F} \cdot d\vec{S} = \int m \frac{d\vec{v}}{dt} \cdot d\vec{S} = m \int v dv = \frac{1}{2} mv^2 \]  
(4)

\[ \frac{1}{2} mv^2 + W_f = 0 \]  
(5)

\[ \frac{1}{2} mv^2 + (-f)x = 0 \]  
(6)

\[ mgh = mgL \sin \theta = \frac{1}{2} mv^2 = f(x) \]  
(7)

The developed activity set consist of manual for teaching and student activity training. It was analyzed Index of Objective Congruence (IOC) by experts 4 persons. Issues for consideration as follows purpose of the activity, content, language use, activities process and activity sheet. The evaluation results found that learning activity set has a consistency index (IOC) from 0.5 - 1.0. This means that STEM learning activity package was correct in content, learning activities and suitable for the purpose.

STEM “Toy car” activity was tested by used to learning management with grade 5 and 6’s students in CMRU demonstration school. (70 persons)

![Figure 3 Learning management STEM “Toy car” activity](image-url)
Students were developed 21st Century learning skills in STEM process. They were learned to work, solved problems and developed creative ideas together. In addition, they also developed communication skill in toy car presentation. The students’ satisfaction level toward STEM process was at a “good” level. It has value of $4.11 \pm 0.71$. Which was corresponding with Praphat's concept that shown in The 2nd International STEM Education Conference 2017. He said that STEM can help students achieve better academic performance. In addition to it was also a practice 21st century skills. [8] Next step, the process was improving according to engineering process. From observing the behavior of students, some students place importance on car decoration which the article of NG King wah Charlie that most girls do not like inventing activities, but like activities that are very decorative. Therefore, STEAM activities should be the activities that develop both people. The researcher adjusted the issue to make use of decorative equipment. [2] Thus, STEM process was developed to STEAM process.

![STEM to STEAM](image)

**Figure 4** STEM to STEAM

Thus, STEM process was developed to STEAM process. The STEAM process of CMRU demonstration school was presented in teacher training in Open house, Faculty of Education, CMRU. Lead to present solution steps in engineering process. In the activity, participants pay attention and exchange knowledge in activities and activities. It was shown in figure 5.

![Participants in STEAM activity](image)

**Figure 5** 5th Step from engineering process “Present solution”

The participants’ satisfaction level toward STEAM process was at a “good” level. It has value of $3.98 \pm 0.54$. Participants, 89.60 percent from 250 persons, were confident that arts can be integral with science mathematics and this activity can be used to improve 21st century learning skills. The results were consistent with the work of researchers of Phetchaburi Rajabhat University. They were developed infographics creating skills of student by using STEAM education.
And, it was alternative way for the students to enhance the quality of learning and develop the 21st century learning skills. [4]

4. Conclusion
A set of “Toy car” learning activity on the basis of STEM education was designed base on engineering process. The products of process were manual for teaching and student activity training. It was tested and improved by participant. Causing changes from STEM education to STEAM education. That was tools in develop student have 21st century learning skill.

Acknowledgments
Author would like to thank Chiang Mai Rajabhat University was financially supported the research grant. Author would like to thank the participants in the development of this activity set, such as students, teachers.

References
[1] Corlu, M., Capraro, R., Capraro, M., “Introducing STEM Education: Implications for Educating Our Teachers for the Age of Innovation”, Education and Science, Vol.39, No.171, 2014, p.74 – 85.
[2] Charlie, NG., “Gender - A critical Factor in the success of STEM (STEAM) Education” Proceedings in 3rd International STEM Education Conference, Bangkok, Thailand, 11 – 13 July 2018.
[3] Funfuengfu, V., “STEM Education and Thailand Education”, Valaya Alongkorn Review, Vol. 7, No.2, May – August, 2017, p.13 – 23.
[4] Keowsawat, P., Keowsawat, P., “Development of infographics creating skills using STEAM education for students in Phetchaburi Rajabhat University”, Proceedings in 2nd International STEM Education Conference, Chiang Mai, Thailand, 12 – 14 July 2017.
[5] Ministry of Education, “Basic Education Core Curriculum”, 2008.
[6] Nakwa, P., Pengudom, S., “Students Grade 7th STEM Development with Enjoyable Activities Case study: Watputtabucha School”, Proceedings in 3rd International STEM Education Conference, Bangkok, Thailand, 11 – 13 July 2018.
[7] See, A., Wang, C., “A Different First Day in the Physics Class at STUST”, Proceedings in 3rd International STEM Education Conference, Bangkok, Thailand, 11 – 13 July 2018.
[8] Thongrak, P., “Integrated STEM Education through 21st Century Skill”, Proceedings in 2nd International STEM Education Conference, Chiang Mai, Thailand, 12 – 14 July 2017.
[9] Urajananon, T., “STEM education Training Model of STEM education Rajamangala Lanna Team”, Proceedings in 2nd International STEM Education Conference, Chiang Mai, Thailand, 12 – 14 July 2017.
[10] Umbua, L., “Developing 21st century skills through the environmental STEM Education Activity on "Energy-Saving Building”, Proceedings in 3rd International STEM Education Conference, Bangkok, Thailand, 11 – 13 July 2018.
[11] Walker, J., “Fundamentals of Physics, Holliday&Resnick, 9th Edition (Extended)”, John Wiley & Sons, Inc., The United States of America.
[12] Chomphuphra P, Chaipidech P, and Yuenyong C 2019. Trends and Research Issues of STEM Education: A Review of Academic Publications from 2007 to 2017. Journal of Physics: Conference Series, 1340 (1), 012069
[13] Sutaphan S and Yuenyong C 2019 STEM Education Teaching approach: Inquiry from the Context Based Journal of Physics: Conference Series 1340 012003
[14] Yuenyong, C. (2019). Lesson learned of building up community of practice for STEM education in Thailand. AIP Conference Proceedings. 2081, 020002-1 – 020002-6.