
Educational Development in PARS Education Circulation System Unit

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Abstract

The purpose of this research aims to enhance grade 10 students' competency on design thinking through STEM education circulation system unit. Qualitative research design, interpretative paradigm, was considered as methodology to analyst and interpret students' performances in representing competency regarding design thinking frame. Participants in this study consisted of 15 Grade 10 students from school in Khon Kaen province. Three weeks lesson plan of STEM circulation system unit activities was employed as an intervention to enhance student's design thinking competency. Research materials for document extraction included students' worksheets, unstructured interview records and classroom observation. Data analysis was conducted through scoring rubrics frame of design thinking competency. Students' behaviors and performances, then, were categorized and developed into pattern with intention to explain the enhancement of students' competency on design thinking. The findings revealed that student' performances on providing clip production about how everyday life activities effect to circulation system represented students' competency on design thinking in excellent level.

Keywords: STEM education, Student's competency, Design thinking, Circulation System

INTRODUCTION

Scientific and technological innovations have been noticeably alerted with the benefits and challenges of both globalization and a knowledge-based economy for being quality citizen in the 21st century (NESDC, 2019; Yuenyong, 2019). To succeed in highly demanded technological society and knowledge-based economy, it is essential for students to develop their capabilities through constructivist approach. The inquiry process will be able to lead learner in the systematic of problem solving, making decision from various reliable information to solve the problems. Through this learning process students not only construct body of knowledge but also acquire other important competency such as creative thinking, critical thinking, collaboration and communication (Brandt, 2010).

However, the quality of education in Thailand have been concern as Office of Nation Education Standards and Quality Assessment (2019) have reveal that the quality of learning achievement in the aspect of ability in critical thinking, analytical thinking, creative thinking, design thinking, and inquiry is quite low. Teaching and learning in 20th century, teachers familiar with traditional teaching style, believe in existing of factual knowledge, emphasizing and transferring crystalized knowledge. The traditional strategy would lead to memorizing rather than understanding and implication. Problems in the real world situation are detached from learning process, it is difficult for students to link and implement theoretical-based knowledge in everyday situations (Tobin et al, 1990; Stone and Lewis, 2012).

Traditional teaching style obstruct students from creative thinking and expressing their thought, these could lead to imitating ideas or event characters as students focusing on memorizing body of knowledge (Brandt, 2010). Whereas, preparing students for being quality citizenship in 21st century students requisite to acquire essential skills for 21st century. Teaching and learning for 21st century is necessary to enhancing student's essential capacities for living in demanded society (Yuenyong,

2019). The important capacity in aspect of learning and innovation composes of creative design thinking and innovation, critical thinking and problem solving, and communication and collaboration (Partnership for 21st century learning, 2011).

Design thinking competency has been considered in this study because design thinking is necessary as central role to drive innovation and change to reach Thailand Strategic Plan (2018 – 2037), which emphasize innovative and entrepreneur citizen for knowledge-based economy. Design thinking is believed one of the most important skills for learning and designing innovation as it is complex thinking process, it could stimulate systematic designing for problem solving (Jobst et al., 2012; Lloyd, 2013). People might familiar design thinking with form of product, however, design thinking could referred as a form of process, creative problem solving method related to thinking method through practicing. Systematic design thinking could be represented in two aspects; thinking and practicing. Thinking aspect may be represented in critical thinking, creative thinking, analytical thinking, and problem solving for designing product or protocol. Practicing may be represented in communication, collaboration, investigation, and production. The design thinking emphasize blended academic in practicing. (Brown, 2008; Liedtka et al., 2013; Buhl et al., 2019; Carlgren, 2016; Stefano et al., 2021). It is claimed that design thinking could be implanted problem solving process skill in sense of framing concept, creative thinking, and critical thinking for students (Choueiri and Mhanna, 2013; Goldschmidt and Rodgers, 2013; Lloyd, 2013). Research from Choueiri and Mhanna (2013) have shown that learning through design thinking enrich both designing and critical skill at the same time. More than that design thinking could assist the novice students who confront trouble on thinking skill through sharing knowledge via brainstorming process (Brown, 2008, Lawson, 2012). Consequently, design thinking seems to develop competency from learning and practicing process in order to frame concept to support students to implement knowledge for designing. The design thinking is claimed designing novice innovation for proper utilization. It is believed to be an important competency for 21st century skills (Tschimmel, 2012). It is essential for science and technology teaching and learning to enhance design thinking as there are rapid increase in technological and innovation demand, problems need more complicated mean to solve. Therefore, design thinking is essential to assist novice mean for problem solving.

An effective instructional pedagogy have to be employed appropriately to ensure that student attain essential knowledge and skills through learning process (Brandt, 2010). STEM education has been promoted as national strategy in Thailand, expecting students to enhance 21st century skills as it is believed to arouse innovative knowledge and skills (NESDC, 2019; Yuenyong, 2019).

Scholars hold STEM education in various means, however, generally STEM education regarded as pedagogical instructions of multidisciplinary approach emphasize practical process of based design for enhancing content and practice bounding the authentic contexts of science, mathematics through technology and engineering process (Bybee, 2013; Chesky and Wolfmeyer, 2015). STEM education activity is related to process of problem solving in social context of real world situation for innovation and entrepreneurship (Stohlmann et al., 2011; Yuenyong, 2019). One of the most important characters of STEM education is active student learning centered, it address practical knowledge and skills rather than body of knowledge (Williams, 2019). So that STEM education is believed to naturally to steer quality 21st century citizenship skills (McDonald, 2016; Bybee, 2010; Sanders, 2009; Moore and Smith, 2014).

There are various STEM strategic approach in Thailand, this research will regard STEM approach from Sutaphan and Yuenyong (2019) which propose seven steps of STEM teaching and learning approach; Identification of social issues stage, Identification of potential solution, Need for knowledge stage, Decision-making, the stage, Development of prototype or product, Test and evaluation of the solution, Socialization and completion decision stage. This teaching and learning approach regard

STEM concept from Moore (2014) considering to bound science and technology in society context (STS).

This teaching and learning approach regard STEM concept from Moore [x], and associate to Science, Technology and Society (STS) considering bounding science and technology in society context.

Students have opportunity to implement inquiry learning process to engage theoretical knowledge, scientific and mathematical knowledge, into engineering design and technological process to create novice innovation in society context. (Yuenyong, 2019).

This study, therefore, keen on developing STEM education lesson plan on Circulation System Unit in order to enhance grade 10 student's design thinking competency through video clip producing activity. During STEM activities, student's design thinking competency was interpreted from student's ideas and performance through worksheets, unstructured interview, and classroom observation. The design thinking emphasized in this study refer to high level thinking process; emphasize, define, ideate, prototype, and test (Institute of Design at Stanford, 2019). Design thinking competency in this study emphasized process skills and social context, the process skills include analytical thinking, reasoning, investigating, creative design thinking, and critical thinking whereas social context refer to collaboration.

METHODOLOGY

This study implement qualitative research methodology regarding interpretative paradigm (Cohen et al., 2000; Creswell, 2014; Yuenyong, 2009). The purpose of the research aims to investigate occurred phenomena of grade 10 students' design thinking competency during participating inquiry process from context-based learning approach of STEM education from Sutaphan and Yuenyong (2019) on the topic of circulation system. The learning performances reflecting students' design thinking competency level were observed and collected through worksheets, unstructured interview records and classroom observation.

Participants

First author is master student in science and technology education programme and science teacher, working in school at Khon Kaen province where the research was carried out. Second author is first author's supervisor and professor in science education at Faculty of education, Khon Kaen University. The third author is PhD. students in science education programme, Khon Kaen University.

The participants in this research were 15 of Grade 10 students, who study in Science-Math program from the small-sized secondary school in rural area of Khon Kaen provinve, Thailand. The research was carried out during classroom teaching in 2020 semester.

Method of inquiry

Indicator and content of Circulation System Unit from grade 10 students from core curriculum had been initially comprehended. Then Circulation System Unit STEM education lesson plan was developed and reflected through professional learning community (PLC) with three authors. Designing activities for promoting as champagne of maintaining good health considering heart rate and relate technology from social network (TikTok) is set. The situation is believed could stimulating student's interest and engage student to harmoniously integrate theoretical knowledge with the activity.

Three Circulation System Unit STEM education lesson plans were designed and implemented in science classroom for three weeks.

This study hold interpretative paradigm, qualitative research design was employed. Qualitative research quality was ensured through trustworthiness; credibility, dependability, transferability, and conformability in this study (Cohen et al., 2000). Data were collected from students' worksheet, unstructured interview and classroom observation. The scoring rubric on design thinking competency was framed regarding the situation on Circulation System Unit STEM education lesson plans, which refer to design thinking in viewpoint of Stanford's design school compose of empathize, define, ideate, prototype, and test (Institute of Design at Stanford, 2019). Data were interpreted, analysed, and developed into pattern in order to understand student's performance according to design thinking competency. In the process of data analysis, the result analysis were clarified and discussed with research members.

STEM-activities in inquiry from context-based learning approach

Purpose of the research aims to investigate phenomenon of grade 10 students' design thinking competency on the topic of circulation system employing inquiry from context-based learning approach of STEM education from Sutaphan and Yuenyong (2019) which composes of seven stages; (1) Identification of social issue, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage.

The idea of designing circulation system STEM activities come up with social issue on "daily activities from waking up to going to bed which affects differentiate of heart rate". As there is the issue of health concerning issue.

The trigger situation starting the Identification of social issues is about enhancing people in your community health participating in activities and monitoring the heart rate. The question trigger STEM activities is "If you desire to enhance healthy of people in your community by encouraging them to do activities that have positive affect to their heart rate or pulsation, who would be your target group? what kind of activity should they engage with? And Why?"

The activities of each stages will be presented in Table 1

Table 1: STEM education circulation system learning activities

Stage	Activity
1. Identification of social issues	1.1 Teacher begin the lesson inspire students to watch video about smart watch 1.2 Teacher and students discuss about advantage of smart watch 1.3 Teacher raise the issue "nowadays people loves to take care of their health, how we could identify whether the activities we do each day affect the blood circulation system" then ask students to discuss about this topic. 1.4 Teacher introduce the activities from starting the day to the end of the day of each day that people normally have partook with, each activities engage different pulsation for example playing football, aerobic dance, running, go up and down stair. 1.5 Teacher and students discuss about pulsation. 1.6 Teacher raise notification for students to consider "If you desire to enhance healthy of people in your community by encouraging them to do activities that have positive affect to their heart rate or pulsation, who would be your target group? What kind of activity should they engage with? And Why?" (worksheet 1)

Stage	Activity
	1.7 Students require to consider whether who would be their target group and why?
2. Identification of potential solution	<p>2.1 The students gather in a group of 4-5 people. Brainstorming about what sort of knowledge they should acquire in order to be able to design proper activity that could have positive affect for the heart rate of certain group of target people. (worksheet 2)</p> <p>2.2 The students identify possible knowledge needed in order to be able explain how that activity affect heart rate of certain group of target people (worksheet3)</p> <p>2.3 Teacher raise notification for students to consider “If you desire to enhance healthy of people in your community by encouraging them to do activities that have positive affect to their heart rate or pulsation, What kind of activity should your target group engage with? And Why?”</p> <p>2.4 Students require to consider whether what kind of activity should the target group engage with, and why?</p>
3. Need for knowledge	<p>3.1 Teacher review previous lesson and guide students that in order to be able to design proper activity for different group of people they might need to understand about biology as the following topics</p> <ul style="list-style-type: none"> - heart - blood pressure - pulsation <p>3.2 Teacher trigger the lesson raising question “Do you notice that why our heart always beat?” (hint: the heart beat because the heart has to pump the blood to circulate to a whole body)</p> <p>3.3 Teacher engage students with blood pressure through watching video about the pumping of blood. (https://www.youtube.com/watch?v=U7ITKUqeuWY)</p> <p>Teacher and students discuss about the topic from this question; What happen if the heart stop beating? (hint: they would be dead.)</p> <p>Teacher encourage students to express their opinion or reasons to their answer from the previous question; Why?</p> <p>3.4 Teacher and students discuss about the relationship of heart, blood pressure, and pulsation</p> <p>3.5 Teacher ask students that if students do not have smartwatch to measure the heart rate, what else could we do to measure the heart rate (hint: we could measure the heart rate by touching at the wrist, or somewhere else that appear to have artery such as the part of the throat under chin that is close to the Adam's apple).</p> <p>3.6 Teacher introduce students to “The activity that affect to the heart rate”</p> <p>Activity: Walk up and down on the stairs</p> <ol style="list-style-type: none"> 1. The students are divided into 3 groups. Students are required to walk up and down the stairs and during that students are required to measure and record the heart rate. <p>3.7 Teacher and students discuss about the heart rate regarding this issue;</p> <ul style="list-style-type: none"> - Average heart rate, and the different heart rate of male and female - Factors effect heart rate such as sex, age, size of the body, mood, stress,

Stage	Activity
	behaviour 3.8 Teacher illustrate about storyboard and how to create and produce storyboard
4. Decision - making stage	After acquiring an ideas about heart rate form the previous stage, students require to make their decision about the activities that reflect positive effect to the heart rate of certain target group, along with supporting reasons. 4.1 Students require to choose the most appropriate concept for their decision making and they have to identify their justification for their decision-making in creating the activity (worksheet 4).
5. Development of prototype and products stage	At this stage, Students require to develop story board first and then produce video clip (tiktok) for promoting the activity of maintaining people health though the designed activity based on the way they have made a decision in the early stage. Students will have to bound their new and existing knowledge and experience to frame the prototype or product 5.1 Students create the story board with 3 minutes the time limitation (worksheet 5) 5.2 Students produce video clip (tiktok) according to their designed story board implementing an application from their mobile phone
6. Test and evaluation of the solution stage	The activities of the test and evaluation of the solution stage were developed to engage each group of students to bring their prototype to evaluate whether the ideas are work well or not. 6.1 Students present their video clip 6.2 The prototype will be evaluated whether activity appropriate to maintain good health for target group people 6.3 Students modify the prototype for the most satisfying prototype.
7. Socialization and completion decision stage	7.1 Students post the video clip on the social network (e.g., Facebook , Youtube, TikTok) 7.2 Students vote the best video clip

Data Collection and Analysis

Nine hours, three circulation system lesson plans were implement as an intervention for design thinking. The data were collected from students' worksheets, unstructured interviews records and participant observation. The students' learning behaviours, verbal and written expressions reflecting their design thinking skills were also observed and interpreted by using qualitative data analysis in 5 steps: Preparing, Segmenting, Coding, Categorizing, and Thematising (Ladachart, 2012). In addition, data were coded to identify students' design thinking skills at their different learning stages as illustrated in Table 2.

Table 2: Data coding and theoretical framework for analyzing and interpreting performances expressing design thinking skill according to the viewpoint of Stanford's design school (Institute of Design at Stanford, 2019).

Topic	Codes	level	Assessment criteria
Empathize	E ₁	Fair	Students can identify the target group but cannot express their understanding about target group.

Topic	Codes	level	Assessment criteria
	E ₂	Good	Students can identify the target group and can express their insight understanding about significant feature of target group (e.g., considering about age, belief and value, religious congenital disease, social status)
	E ₃	Excellent	Students can identify the target group and can express their insight understanding about significant feature of target group (e.g., considering about age, belief and value, religious congenital disease, social status) and be able to employ reliable data collection mean such as documentary or interviewing to comprehend insight information and significant feature about the target group.
Define	D ₁	Fair	Students can identify the activity that affect the pulsation
	D ₂	Good	Students can identify the activity that affect the pulsation and considering the connection of the activity to the target group.
	D ₃	Excellent	Students can identify the variety of activities that affect to the pulsation considering the connection of the activities to the target group with as many specific details as possible
Ideate	I ₁	Fair	Students can generate at least one possible solution for the problem
	I ₂	Good	Students can generate more than one possible solutions for the problem
	I ₃	Excellent	Students can generate various dimensions of novice possible solutions for the problem
Prototype	P ₁	Fair	Students can create the storyboard according to the objective from the given situation
	P ₂	Good	Students can create the storyboard according to the objective from the given situation, can express justification the possibility of producing storyboard associate to objective from the given situation
	P ₃	Excellent	Students can create the storyboard according to the objective from the given situation, can express justification the possibility of producing storyboard associate to objective from the given situation, and can defence or come up with the idea of modification when the prototype is criticised
Test	T ₁	Fair	Students do not reflect the feedback for improving the storyboard.
	T ₂	Good	Students reflect the feedback for improving the storyboard in some dimension
	T ₃	Excellent	Students reflect the feedback for improving the storyboard properly

RESEARCH FINDING

This research aim to enhance students' competency on design thinking. Students' performances during the process of creating activity affect to heart rate were interpreted in order to assess their design thinking skill. Through STEM education students require to create storyboard and video clip based on Thailand Biology content standard about the circulation system. STEM education Circulation System Unit were implement to students the classroom dividing into six groups, however, there were only three groups that were able to complete the assigned tasks. It is interesting that other three groups that were not be able to complete the assigned task because of their personal reasons such as pregnancy, discontinuing school because of financial reason, family reason or their own reason.

The findings section will be demonstrated into two aspects; (1) what and how students develop ideas for designing activities effect heart rate through STEM education, and (2) overview of students' competency on design thinking.

What and how students develop ideas for designing activities effect heart rate through STEM education

This section will present about what and how students develop ideas for designing activities effect to heart rate through STEM education. Students design various kind of activities effect to heart rate; group 1 lady bug; volleyball, group 2 Sittichok; aerobic dance, and group 3 Angle; running. This section will clarify what and how students in group 1 ladybug develop ideas for designing and producing prototype as an example. There are 5 students in ladybug, their academic achievement are in quite high level compare to students in the same classroom. Members in this group are confident to express their idea as they always cooperate and participate in activities in the classroom.

The ladybug obtain design thinking competency on the aspect of define and ideate in good level whereas they achieve empathize, prototype, and test in excellent level. The level of achievement in each aspects on design thinking were tracking and analyst as follow;

Design thinking competency on Empathize.

In identification of social issue stage, group1 obtain good level of emphasize as after watching video clip about smart watch then students require to work out the issue in worksheet 1 which state that "If you desire to enhance healthy of people in your community by encouraging them to do activities that have positive affect to their heart rate or pulsation, who would be your target group? And Why?"

"Golden age group, because these people have to exercise regularly to increase heart rate otherwise they are risk for having blood pressure in high level" (Ladybug1)

"Hypertension group, because exercise plays a part in helping to control blood pressure. If you exercising regularly it will help reducing the pressure in the circulatory system" (Ladybug 2)

From these answers, it could be interpreted that students achieve empathize skill in a good level as students can identify the target group; *Golden age and Hypertension*, and they attempt to express specific features relate to the age range and underlying disease of the target group. However, the students did not achieve excellent level as they were not show the reliability of their statement regarding specific feature of those target group. It seems that students make that claim based on their existing knowledge and experience rather than refer to reliable method and sources.

Nevertheless, in Decision making stage, students reconsider about target group and achieve excellent level of empathize.

After acquire knowledge needed in need for knowledge stage, students require to make decision together with team member on creating activity for maintain positive effect on heart rate for certain group of people (worksheet 4). The ladybug have changed their target group to school athlete and the activity they think could help school athlete to maintain their health is playing volleyball.

Teacher: *Why do you think, playing volleyball is good for school athlete?*

Ladybug 2: *Because playing volleyball is easy to practice, all ages and sex could play and it is good for health. Playing volleyball could help to increase heart rate which consequently good for blood circulating rate. Normally, average heart beat is 60-80 beats per minutes, however, for a person who is physically strong like sportsman, pulse rates would be lower than that, which could be 40-60 beats per minutes. Whereas people who are not really strong, their heart rate would be 70-80 beats per minutes*

The ladybug do research further about heart rate and circulation system and add the information that *“For people who do not usually exercise, their heart rate would be about 70 beats per minutes. If you exercise to maintain healthy such as walking, running, swimming, biking, and aerobics dance 30 minutes a day 3-5 times a week, after doing it for 3 months, the pulse may only beat 50-60 per minutes. School athletes are already a strong group of people as they play sports regularly, therefore, if using a group of school athletes as target group for producing video clips in the TikTok application, it might provide a clear vision on illustration activities that affect heart rate.*

In Decision making stage, Ladybug team member narrow down target group to school athlete. It is show that student consider social status of the target group, and make it as criteria for making their decision. More than that, the ladybug achieve excellent level of empathize skill for design thinking as it could be clearly seen that Ladybug show the tracking evidence that they do research on average people and athlete heart rate and circulation system to help them comprehend target group.

Design thinking competency on Define

Design thinking competency on define aspect was acknowledged in identification of social issue stage. Ladybug achieve define skill in good level as it was analyzed from activity in the identification of social issue stage where students require to define problem frame from and potential solution (create activity) for target group in order to maintain their heart rate in a healthy mean from the raised situation.

“If you desire to enhance healthy of people in your community by encouraging them to do activities that have positive affect to their heart rate or pulsation, What kind of activity should your target group engage with? And Why?”

The ladybug refer to *Golden age and Hypertension* group in their first hand. So when they had been asked about the activity for those group of people, the Ladybug 3 suggest running as they believed that *“run, because running helps to burn a lot of energy. If you run every morning, it could enhance the quality of your health and heart”*

It could be interpreted from the answer that student can identify activities that affect to heart rate in consideration of target group. Students related the activities with some other reason; *running helps to burn a lot of energy*, which was not relate to empathize. Effective of the activity to heart rate for *Golden age and Hypertension* people in order to maintain their healthy was not really been considered. Therefore, the Ladybug obtain fair level of define skill.

Design thinking competency on Ideate

Identification of potential solution stage could measure the design thinking process on ideate skills from worksheet 2 and worksheet 3. Activity in worksheet 2 require students to brainstorm knowledge needed in order to create activity promoting people health considering the relation of target group and heart rate.

“we need to know daily behavior of target group, and we need to know about how cardio exercise increase heart rate?”

It could be seen that the Ladybug could not identify knowledge needed to generate potential solution for the situation. It seem that thy mention about increasing heart rate without understanding.

Another activity in Identification of potential solution stage require students to identify possible knowledge needed in order to be able explain how that activity affect heart rate of certain group of target people (worksheet3). This activity intend students to discover knowledge about how each activity affects heart rate.

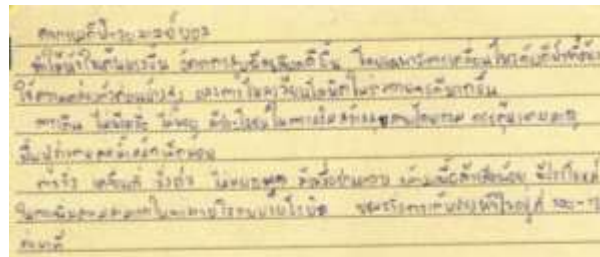


Figure 1: The Ideate Worksheet

Students recommend three activities; volleyball, walking and running, as exercise activities which effect heart rate. ***“Volleyball*** is an activity that increase the heart rate, and increase blood pumping rate in the body. Particularly it is a kind of sport that requires relatively high movement, consequently it improve blood circulation in the body. ***Walking***, without sweat and gasp, enhance overall health, stimulate metabolism and could lighten weight. ***Running***, with sweat and gasp, help to increasing aerobic breathing capacity, the heart rate would be about 100-120 beats per minute during running”.

It could be seen that student propose three exercise activities for assisting the target group to maintain healthy. The Ladybug employ scientific knowledge related to circulation system. *“Volleyball is an activity that increase the heart rate, and increase blood pumping... sport that requires relatively high movement... it improve blood circulation in the body”* to explain how that activity affect heart rate. The ladybug obtain good level of ideate skill as the Ladybug failed to offer various dimension of activities.

Design thinking competency on Prototype

Development of prototype or product stage can be implemented to evaluate design thinking on prototype skill. In this stage, students require to develop story board first and then produce video clip (tiktok) for promoting the activity of maintaining people health.



Figure 2: student's storyboard

The storyboard provide picture of volleyball playing without having explanation of the activity with the effective of heart rate. Therefore, it could be analyzed regarding scoring rubric that the Ladybug obtains prototype skill in fair level. Although the Ladybug could create indeed beautiful storyboard about playing volleyball which corresponds to the objectives set in the decision stage, they failed to express justification the possibility of producing storyboard associate to objective.

The Ladybug obtain fair level on prototype skill in the first hand, however, the storyboard had been improve regarding suggestion from teacher and peers. The improve version of storyboard from the Ladybug is shown in Figure 3.

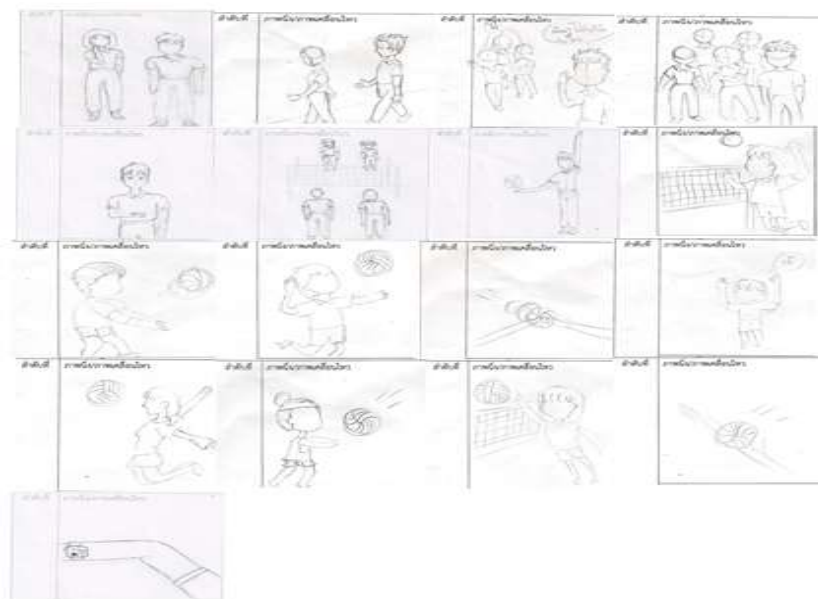


Figure 3: The improve version of Ladybug's storyboard

From storyboard in figure 3, it could be seen that the Ladybug could modify storyboards adding explanation about justification the possibility of producing storyboard associate to objective, and process to modify the concept is described. The Ladybug improve the procedure to engage target group in the first scene, and add heart rate measurement before and after doing the activity into storyboard. So, the Ladybug achieve excellent level on test skill after modification.

Design thinking competency on Test

In test and evaluate the prototype or product stage, it is employed to evaluate design thinking on test skill. Student require to produce and present video clip on activity promoting champagne of maintaining good heart rate for target people in community.

The Ladybug obtain fair level on test skill in their first hand as their original video clip did not express about target group, defining problem, and generating idea for potential solution. It also did not specify how playing volleyball affects heart rate. The first version of Ladybug video clip has shown in TikTok application (<https://vt.tiktok.com/ZSJ2bySde/>)

The Ladybug improve their video clip, the improve version of Ladybug video clip has shown in TikTok application (<https://vt.tiktok.com/ZSJDrgyIt/>). In this version, the Ladybug reflect feedback and suggestion adding expression about target group, defining problem, and generating idea for potential solution. The improved video clip version demonstrate positive effect of socialization and completion decision outcomes.

Overview of students' competency on design thinking

This study reveal that students' performance could be interpreted regarding design thinking competency. Through STEM activities, students have to consider problem from the situation, collect the idea regard to defined problem, generate idea, planning, and test their idea. Students' performance could demonstrate the capability of their design thinking in five aspects; empathize, define, ideate, prototype, and test.

The details of design thinking skill expressed in the context of STEM education activities in each stage are shown in Table 3.

Table 3: Details of student's design thinking competency expressed in the context of STEM education

Group	Student design thinking competency					
	Stage 1	Stage 2	Stage 4	Stage 5	Stage 6	Stage 7
1:Ladybug	E ² D ²	I ²	E ³	P ¹	T ¹	P ³ T ³
2:Sittichok	E ¹ D ²	I ²	E ²	P ¹	T ¹	P ³ T ³
3:Angle	E ¹ D ³	I ³	E ³	P ¹	T ¹	P ³ T ³

According to the table 3, stage 1 refer to identification of Social Issue Stage

Stage 2 refer to identification of potential solution stage

Stage 4 refer to decision-making stage

Stage 5 refer to development of prototype or product stage

Stage 6 refer to test and evaluate the prototype or product stage

Stage 7 refer to socialization and completion decision stage

E refer to Empathize

D refer to Define

I refer to Ideate

P refer to Prototype

T refer to Test

Number 1, 2, 3 refer to design thinking competency level regarding scoring rubric criteria from table 2; level 3 refer to excellent, level 2 refer to good and level 1 refer to fair behavior.

This finding reveal that through STEM education on designing activity promoting the champagne on maintaining healthy, the STEM education activity could noticeably enhance student's design thinking skills

Students from three groups (5 students in each group) produce video clip (TikTok) about how everyday life activities effect heart rate. Consequently, student would consider the important of their everyday activity relate to heart rate and health. Two groups of students' performances could be evaluated achieving excellent level of design thinking skills as they gain excellent level form more than three aspects; group 1 and 3. Group one achieve excellent level on three aspects; empathize, prototype and test, whereas group 3 achieve excellent level on all aspects.

However, it is interesting that two groups of students obtain good level on design thinking skill in define and ideate aspect, as shown in Table 4.

Table 4: Results of students' competency on design thinking

Design thinking competency	competency level		
	1:Ladybug	2:Sittichok	3:Angle
Empathize	Excellent	Good	Excellent
Define	Good	Good	Excellent
Ideate	Good	Good	Excellent
Prototype	Excellent	Excellent	Excellent
Test	Excellent	Excellent	Excellent

Regarding results from table 4, the Ladybug attempt to design volleyball activities maintaining positive effect to heart rate. Figure 6 show the first and modified version of storyboard and video clip instructed through STEM activities. It reveal that the Ladybug achieve excellent level of design thinking competency in the following aspects: empathize, prototype and test, whereas define and ideate are assessed at good level.

Original video clip



<https://vt.tiktok.com/ZSJ2bySde/>

Improve version of storyboard and video clip



<https://vt.tiktok.com/ZSJDrqyJt/>

Figure 6: First and modified version of storyboard and video clip through STEM education activity

The Sittichok endeavors to design aerobic dance activities maintaining positive effect to heart rate. Figure 7, show the first and modified version of storyboard and video clip instructed through STEM activities. The finding reveals that the Sittichok achieve excellent level of design thinking competency in the following elements: prototype and test, whereas empathize, define and ideate are evaluated at good level.

Original video clip



<https://vt.tiktok.com/ZSJDgXGsu/>

Improve version of storyboard and video clip

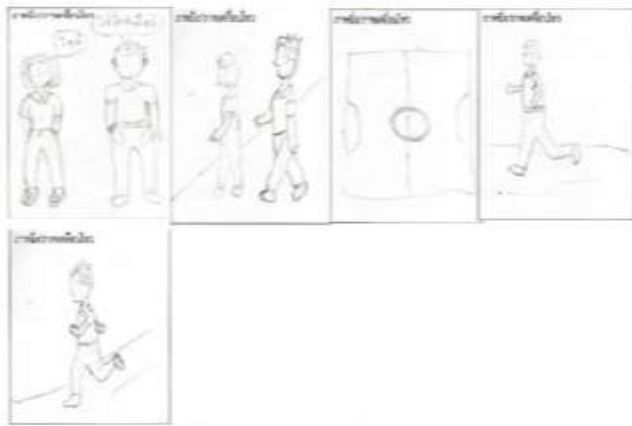


<https://vt.tiktok.com/ZSJDkYkMA/>

Figure 7: First and modified version of storyboard and video clip through STEM education activity

The Angle attempts to design running (jogging) activities maintaining positive effect to the heart rate. Figure 8, show the first and modified version of storyboard and video clip from STEM activities. It is interesting that the Angle achieve excellent level of design thinking competency in all aspects: empathize, define, ideate, prototype and test.

Original video clip



<https://vt.tiktok.com/ZSJUUjpxD/>

Improve version of storyboard and video clip



<https://vt.tiktok.com/ZSJDm3sqH/>

Figure 8: First and modified version of storyboard and video clip through STEM education activity

The research on enhanced grade 10 students' competence on design thinking instructed through STEM education activity on the situation of designing champagne for maintaining health, regarding scientific concept of the heart rate, the study exposes that students should consider about social issues (maintain healthy) and attempt to reach for solutions, regarding problem solving from that situation. Student-centered was consider as teaching and learning strategy throughout STEM education activities, students were stimulated to participate with the process of thinking through practicing design thinking activities. The activities were usually organized through teamwork as the

intention to embed students on collaboration skill. It is claimed that design thinking could assist the novice students who confront difficulty on thinking skill through sharing knowledge via brainstorming process (Brown, 2009, Lawson, 2012). Circulation system concept was harmoniously blended with the social situation and TikTok production.

Students' design thinking competency was interpreted from students' performance and expression during STEM education activities. Formative assessment was implemented in this study, there was no grades or marks, throughout the activity students were not judged rather reflect for improvement, students also have opportunity to express their ideas without obstruction. Performance evaluation had made after students have reflect to the feedback. Design thinking scoring rubric had implemented as assessment criteria to evaluate students' design thinking competency through worksheets, unstructured interviews, and classroom observation.

CONCLUSION

This research aim to enhance student's design thinking competency as it is believed that design thinking lead to improvement in various dimension such as high level of thinking, problem solving, transforming innovation (Jobst et al., 2012; Lloyd, 2013). STEM education was considered as appropriate approach to enhance student's competency through constructivist and transformative learning (Chesky and Wolfmeyer, 2015). The research was organized through circulation system for grade 10 students.

The finding reveal that design thinking competency could be enhanced through STEM education activity as it allows students to construct the knowledge through problem solving practicing. Teaching and learning activities on circulation system were harmonious blended through STEM learning approach, setting situation for students to create champagne for maintaining health through video clip production, in order to enhance design thinking competency. There was five aspects of design thinking competency; empathize, define, ideate, prototype and test. It could be seen that two from three groups achieve excellent level of overall design thinking competency, while one group obtain good level as they fail to reach excellent level in three aspects; empathize, define, ideate. It could be seen that all three groups achieve excellent level in prototype and test, they did not reach excellent level in their first hand, the excellent level was awarded after they reflect their work to the feedback. This imply that formative assessment is indeed appropriate to enhance student's competency, students could be improve their skills through reflecting from feedback rather than grading (Sohosmboon and Yuenyong, 2021). Improve from feedback had also occurred on empathize skill, the empathize skill was evaluate in two stages; stage 1 and stage 4. At first time in stage 1, Ladybug obtain good level whereas Sittichok and angle obtain fair level, however, Ladybug and Angle achieve excellent level, and Sittichok improve to good level in stage 4.

This assumption could be implied that in term to improve student's define and ideate skill teacher might need to reflect their work and idea, and give opportunity for students to consider to develop their idea further. Students could have potential to enhance their skill reaching excellent level.

In brief, it is important to enhance student's competency for being quality citizen in 21st century, and design thinking is one of the most important skills driving technological and innovative society. STEM education seem to be one of the most appropriate approach enhancing student's competency, and it is evidently from this research that STEM education harmoniously improve student's design thinking competency on the circulation system. Furthermore, another indeed important factor supporting competency improvement is formative assessment, design thinking competency in this study was improved through reflection from feedback. Student's idea and thinking do not have to assess solely through exam, it could be evaluate and improve through performance.

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