ISSN 2090-3359 (Print)
ISSN 2090-3367 (Online)

ΑΔΣ

Advances in Decision Sciences

Volume 24
Issue 2
June 2020

Michael McAleer

Editor-in-Chief
University Chair Professor
Asia University, Taiwan

Published by Asia University, Taiwan

ADS@ASIAUNIVERSITY

Decision Sciences in Education: The STEMtech Model to Create Stem Products at High Schools in Vietnam*

Ngo Tung Hieu

Nguyen Dinh Chieu High School, Tien Giang, Vietnam

Lam Minh Huy

Department of Mathematics, College of Natural Sciences, Can Tho University, Vietnam

Huynh Manh Phat

Department of Mathematics Education, Teachers College, Can Tho University, Vietnam

Nguyen Ngoc Phuong Anh

Department of Mathematics Education, Teachers College, Can Tho University, Vietnam

Wing-Keung Wong*

Department of Finance, Fintech Center, Big Data Research Center, Asia University, Taiwan

Department of Medical Research, China Medical University Hospital, Taiwan

Department of Economics and Finance, Hang Seng University of Hong Kong, China

Revised: June 2020

* The authors are grateful to a reviewer for helpful comments and suggestions.

*Corresponding author: wong@asia.edu.tw

Abstract

In the recent digital age, Decision Science plays an important role in many areas, including Education. Among the Educational trends that serve the fourth industrial revolution, STEM Education has been demonstrating its superiority through various studies from Europe to Asia. This study applies the STEMTech model, a model that connects the fields of Science, Technology, Engineering, and Mathematics to create products with a central technological factor, to create STEM products in the context of High Schools in Vietnam. We first design the survey questionnaires and distribute the questionnaires to respondents to get our survey done. We then carry out a quantitative analysis to evaluate rubric and find positive feedback from students, the model provides a new approach to teaching in High Schools in the industrial age 4.0, helps students create STEM products and have a dynamic and creative learning environment, and helps teachers to create modern tools and approaches. The real-life applications of the STEM products show the suitability, vitality, and potential of applying the STEMTech model when it comes to teaching.

Keywords: Decision sciences in education, STEM education, STEM products, STEMTech model.

JEL: A21, A22, !21.

1. Introduction

The world has been entering the fourth industrial revolution; that is, Industry 4.0. According to Schwab (2016), Industry 4.0 develops based on three main pillars, including Digital, Biology, and Physics. With features emphasized by artificial intelligence, everything will be connected to the Internet, Robotics, Autonomous Vehicles, 3D Printing Technology, Nanotechnology, Biotechnology, Materials Science, Energy storage, and Quantum computing. The development of the fourth industrial revolution requires urgent new human resources in the world. So, in this new environment, which educational model could link all these areas into human resources? One of the best answers is to use the STEM education model. An important feature of the STEM educational model is that learners create practical products to link all the above-mentioned areas into practice.

STEM is an abbreviation of Science, Technology, Engineering, and Mathematics. In the industrial age of education 4.0, the STEM educational model is increasingly receiving great attention from educators around the world. The National Science Teachers Association (NSTA), founded in 1944, proposed the concept of the STEM education with the following definition: "STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply Science, Technology, Engineering, and Mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy" (Tsupros et al., 2009).

It can be observed from the above definition that, there are three important characteristics when talking about using the STEM educational model: Interdisciplinary approach, creating application products into practice, and connecting schools and communities to global organizations. Through STEM educational training, students are able to develop the following skills: problem-solving, creativity, analysis, critical thinking, independent thinking, teamwork, communication, and information technology skills. It can be said that this is an educational model that meets all the requirements of the Industrial Revolution 4.0.

The STEM educational model has been widely applied effectively in many countries around the world. Many authors all over the world have been discussing the model. For example, Basham, Israel, and Maynard (2010) from the United States, Andrée and Hansson (2013) from Swenden, Bissaker (2014) from Australia, Debes (2018) in Cyprus, Zendler (2018) from Germany, etc. In Asia, the STEM educational model is also getting good attention in numerous countries including Malaysia (Osman & Saat, 2014) and China (Zhao, 2019). In general, these models aim to apply the STEM educational models in different contexts, subjects, and levels of study; for example, Chen & Chang's (2018) research conducted at high school, while Zhao's research (2019) choose the preschool child. New technology studies are also included as 3D printing technology in Lin et al.'s (2018) study.

Nevertheless, many STEM educational models are still based on the old foundation, not paying adequate attention to the central role of new technology in the digital age today. Therefore, it is necessary to improve the STEM educational model with a focus on new technology. The most appropriate and updated model is the STEMTech model developed by Tuan, Pho, Huy & Wong (2019). This STEMTech model was formed from the support of Arizona State University (USA) through the BUILD-IT project. It is characterized by emphasizing the technological element as shown below in Diagram 1.

The STEMTech model has two basic characteristics: (1) Learners practice and experience new technologies; (2) STEM products made by learners must be creative and based on these new technologies. New technologies here are understood as technologies that learners never knew. These new technologies are not necessarily new to the scientific community. It can be said that the STEMTech model, when put into teaching, has the advantage of helping learners create STEM products based on technology. Tuan et al. (2019) showed the effectiveness of this model when applying it in a university environment.

It has been seen that a research question is required in the practical situation that is:

Question Q: "How to apply the STEMTech model to create STEM products in the context of High School?"

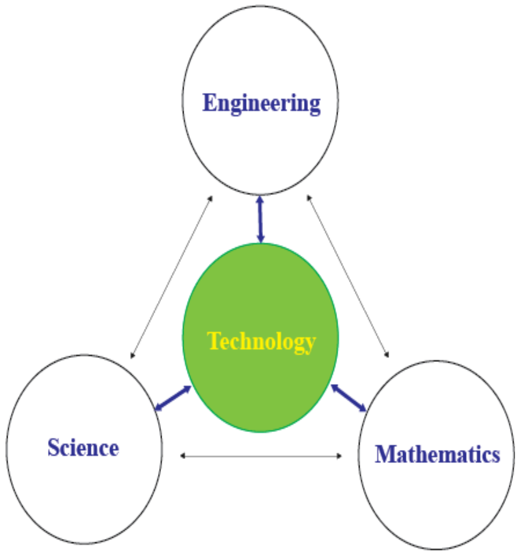


Diagram 1

STEMTech model in which Technology is the central element

In order to answer this question, the article conducted an empirical study in Can Tho city, Vietnam. The rest of the paper is organized as follows. We review of STEM products and Technology elements in Section 2. In Section 3, we introduce data and methodology. Discussing the empirical analysis is provided in Section 4. Concluding remarks and inference will be presented in the last section.

2. Literature Review

2.1 STEM Products

STEM products are products that learners apply knowledge and skills in the fields of Science, Technology, Engineering, and Mathematics (STEM) to be applied to life. The STEM project is understood to be a project designed for learners to create STEM products. According to Capraro et al. (2013), the STEM project provides practical, contextual experiences for students to enhance learning and build strong scientific, technological, technical, and mathematical concepts. Learning through the STEM project is both challenging and motivating. It requires students to think critically, analyze, and improve higher-order thinking skills. Moreover, it also requires collaboration, peer-to-peer communication, problem-solving, and self-directed learning while working closely with all students.

The STEM project builds on Technical design that is the foundation for students to bring their Scientific, Technological, and Mathematical knowledge to solve meaningful practical problems. Instead of teachers telling students what to do, students must work with friends to identify problems and find ways to solve problems during STEM project implementation. Students then have the opportunity to build their own knowledge, instead of traditional classroom, content dissemination teachers for students (See Ozel, 2013). The goal of the STEM project is to help learners gain knowledge, deep understanding of knowledge, learn skills, and practice discipline (Barron et al., 1998).

2.2. Technology elements

2.2.1. Application of 3D technology in teaching

A study completed in 2000 by the Canadian National Research Council, compared the standard 2D classroom experience to the 3D class for students participating in the wood gathering. Students participating in 3D virtual training have increased the volume of exploited wood by 23% while reducing the 26% mistake as well as the cost of repairing and maintaining vehicles. Since then, the application of 3D technology in teaching has helped students better understand the lesson. Therefore, it is possible to bring different types of 3D technology into current teaching such as 3D Scanning, 3D Printing, 3D Designing, etc. to create a learning environment for students to feel more excited and the amount of comments consciousness will absorb better.

2.2.2. Scratch

Scratch is designed and maintained by Lifelong Kindergarten teachers at the Media Lab of Massachusetts Institute of Technology (USA). This program is completely free. Currently, Scratch is used for all ages. Scratch is available in more than 150 countries and has more than 40 languages including Vietnamese. Besides, Scratch is also an online community where children can program and share interactive media like stories, games, and animations with all friends around the world. Scratch helps young people learn creative thinking, systematic thinking, and collaborative work - these are the skills needed for life in the 21st century.

Programming on Scratch is done in a very intuitive way, it allows to "assemble" the blocks of commands, commands as a puzzle game with drag and drop operations to perform functions to control character objects, perform tasks, and describe events, etc. to help users design and build up programs. Scratch is very suitable for teachers to create products for teaching such as knowledge simulation, lesson modeling, lectures, e-books, learning applications, etc.

2.2.3. Qlone – Scanning 3D

Qlone is an application on the phone, is a free application available on IOS and Android. It is an application that uses the phone's camera to scan a real sample, then can export to many 3D formats such as images, videos, etc. In addition, you can edit details when Scanning errors on your phone, such as editing layouts, colors, sizes, etc. to help with 3D printing. Qlone is an application owned by EyeCue Vision Technologies LTD, a technology company in Yokneam, Israel founded by Ronen Horovitz - CEO.

3. Data and Methodology

In order to answer Q, we conducted a pedagogical experiment with the following process:

Step 1: Providing students with knowledge about STEM education, STEMTech model.
Step 2: Dividing 39 students of class 11A1 from the High School of Can Tho University (HSCTU) into 4 groups to implement 4 STEM products (ball shooting machine, vacuum cleaners, decorative lights, 3D collections) from 07/01/2019 to 26/01/2019.
Step 3: Selecting a product and organizing a STEM product design competition between 08 classes in HSCTU (10A1, 10A2, 10B1, 10B2, 11A1, 11A2, 11B1, 11B2) for nearly 1 month (25/02/2019 – 23/03/ 2019).
Step 4: Using rubrics and questionnaires to survey students in the experiment.

We present four experimental STEM products in the next sub-section.

3.1 Ball shooting machine

3.1.1 Content

Students design ball-shooting machines based on elastic force. The machine will be judged from the accuracy of the shot.

3.1.2 Goal

This product will create a potential playground to stimulate and promote students' creative thinking and computational thinking, thereby helping them to better understand STEM education. In addition, students can apply the knowledge of Science, Physics, and Engineering to create a ball shooting machine. Using Mathematics and Information Technology skills to calculate parameters to shoot targets accurately and effectively.

Furthermore, this product will help students simulate war weapons in previous periods. Making tennis practice machines. It also helps to develop some skills for students such as teamwork, communication, collaboration, ability to think critically, and solve problems. Besides, it also helps to facilitate the exchange and connection among students, between students and teachers.

3.1.3 The process of implementation

Step 1: Students need to learn about materials to create elastic forces and select and prepare materials, and then design the model of the shot machine.

Step 2: We divided into 2 groups: the first group designs gun barrel and parts to create a shooting force. The other group was assigned to tripod design and shot angle adjustment.

Step 3: Assembling machine parts.

Step 4: Perform a test shot, create a corner calculator to accurately shoot and adjust the machine (if needed).

3.1.4 Product

About the structure of the machine, it can be observed from Figure 1 that, the gun barrel is made of round plastic pipes 8cm in diameter, 1m long and it has 2 slots for pulling force. Besides, we designed rubber sheets to stick in the gun barrel to fix. Parts for shooting force is designed to be a set of elastic strings from the car gut, we use a horizontal iron bar as a fulcrum. The rotating shaft between the gun barrel and the tripod is used to shot angle correction. The foot of the ball shooting machine is made up of 2 wooden beams of 10x50x1cm in size, and the other wooden plate as the base of the ball shooting machine.

Principle of operation: The ball is placed in a fixed position in the barrel, the rope is pulled out when released the elastic force created by the rope will affect the ball, the ball is shot in the direction of the barrel.

How to calculate the initial speed: Enter the shot angle, coordinates the endpoint of the ball when shooting. How to calculate the shooting angle: Enter the initial velocity, target coordinates.

3.1.5 Project analysis

Four elements of STEM during project implementation:

Science: Using knowledge of materials with good elasticity, knowledge of the durability of materials.

Technology: Design of digital tools to calculate shooting angles.

Engineering: Machining and assembling parts of the machine.

Technology elements: Calculation tool from Scratch software

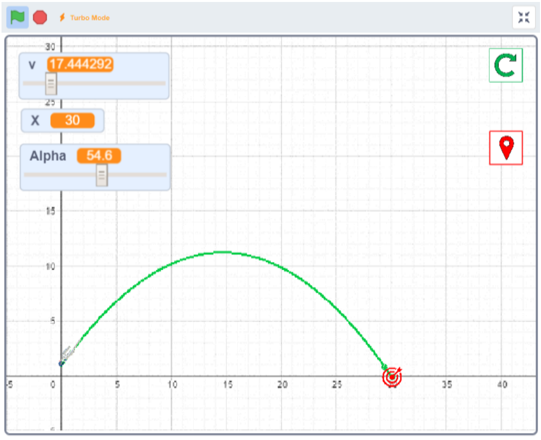


Figure 2

A Tool to calculate the shooting angle

Mathematics: Calculate, estimate the dimensions of the parts in the idea-making process. Transform the trigonometric equation, the second-order equation from the skew throwing formula, calculate the error, thereby giving the angle calculation formulas.

Advantages and disadvantages in the project implementation process:

About the advantages, it can be seen that the materials are easy to find. Nevertheless, during the implementation process, there are also certain difficulties that are: The friction of the materials changes the shooting angle and shooting force. The calculation to accurately target a difficult target.

3.2. Vacuum cleaner

3.2.1 Content

Students can apply knowledge about electrical circuits, power sources, motor, convection to design mini vacuum cleaner. The purpose of this device is to help absorb pollen grains on the board, podium, and contribute to clean the classroom and protect the health of students and teachers.

3.2.2 Goal

Students can understand the creation of a complete circuit. In addition, helping students gain a more basic understanding of machines so that they can learn more about complex machines later. Moreover, students can practice ingenuity and creativity to create space for vacuum cleaners.

3.2.3 The process of implementation

Step 1: Learn how the vacuum cleaner works. Students will have to learn the principle of how to get dust into the machine: Rotation of the impeller (rotation, the direction of rotation), the position of the vacuum cleaner, how to design the dust filter.

Step 2: Students design casing and dust collectors. Students choose materials for the vacuum cleaner casing (originally recycle or print 3D cases). After acquiring the student case, the space of the case will be divided into 3 parts: The power supply part may be a rechargeable battery, motor storage part with propeller, and the dust container is separated from other parts by the screen.

Step 3: Select the appropriate motor and power source. For the wings to work effectively, students must calculate the power, voltage of the motor, and the voltage of the power source so that the

rotor rotates as hard as possible. In addition, students must calculate the time of use of the power source corresponding to the motor used to know the time required to recharge the power source.
Step 4: Assembling details and completing products. Students need to calculate and choose the order of assembling details into the vacuum cleaner in order: Vacuum cleaner case and tap, filter screen to divide the machine into compartments, motor and rotor, and electric circuit to connect with a power source.

3.2.4 Result

Technology elements: The rechargeable battery will provide power to the engine, when the rotary motor will generate air circulation to attract dust into the screen, then the filter keeps dust.

3.2.5 Project analysis

Four elements of STEM during project implementation:

Science: Application of the principle of air circulation, using knowledge of the compatibility between power and voltage potentials.
Technology: Contact with technology equipment such as motor, rechargeable battery.
Engineering: Machining and assembling parts of the machine.
Mathematics: Rationally use the learned formulas to calculate the voltage, the capacity of the details to select the appropriate materials.

Advantages and disadvantages in the project implementation process:

About the advantages, it can be seen that models are available, easy to reference. This machine tested well the first time. Nevertheless, during the implementation process, there are also certain difficulties, for instance: The model is quite bulky and heavy. It is necessary to find ways to reduce the volume of the machine.

3.3 Decorative lights

3.3.1 Content

Students use the nature of electricity in electrolytes to design decorative lamps in bedrooms. For the purpose of use, helping to save electricity, living costs as well as environmental protection in decoration.

3.3.2 Goal

Students can understand and follow the STEM project implementation process. Besides, students understand the nature of electricity in electrolytes. In addition, train students to use metal wires to generate electricity and use an ammeter to measure the intensity of the current. When designing decorative lights, students also have the ability to calculate and accurately measure the current of the electrolyte to make the lights suitable.

3.3.3 The process of implementation

Step 1: Learn knowledge about electrolytes, wires, and LEDs. Select and prepare some electrolytes, wires, lamps.

Step 2: Dissolve the selected electrolytes and mark so that the solute solution must have the same concentration.

Step 3: Measure the current and voltage of the current generated in the electrolyte solution selected and fill in the datasheet. After measuring the current and voltage, students will fill in the following data and tables.

Step 4: Select electrolyte and lamp type, number of suitable lights and proceed with decorating products.

3.3.4 Result

The group of students created a decorative light model. About the structure of the decorative lights, it can be observed from Figure 4 that, NaCl solution and water, plastic cups, lead wires, and copper wires are used to make electrical and transmission parts. LEDs are used to make glowing parts. In addition, we use paper boxes and other materials to make decorative parts.

Technology elements: The electrolytic NaCl solution produces Na^+ and Cl^- ions, connecting lead wires and wires (copper) in series, copper wire is an anode, while lead is negative, electric current will go from positive to negative and to light bulb light up.

3.3.5 Project analysis

Four elements of STEM during project implementation:

Science: Application of knowledge related to the nature of electric current in electrolytes, the process of measuring the concentration of solutions in the laboratory.

Technology: Using equipment such as weighing the mass of chemical sand, super-stirrer, Ammeter, voltmeter, etc.

Engineering: Machining, assembling the parts of the product.

Mathematics: Students can create equations to describe numbers and relationships, rearrange formulas to highlight the value of interest, use that argument to solve equations. for example, using a formula to calculate the concentration of solution to calculate the volume and the number of moles of electrolytes. Solve practical, mathematical, physical, and chemical problems by setting up and solving equations. Helping students know how to analyze accuracy and errors in measurement conditions. Moreover, students understand the concept of scale and use the ratio to solve problems.

Advantages and disadvantages in the project implementation process:

About the advantages, it can be seen that the structure of decorative lights is very simple and easy to implement. Nevertheless, during the implementation process, there are also certain difficulties, for example, the weak current is not enough to light the normal light bulb (The project team will continue to find ways to overcome).

3.4 3D scan collection

3.4.1 Content

Application of 3D Qlone scanning software to scan the collection of shellfish species. For the purpose of use, help students have more sources of rich reference materials, serving the study of Science in High Schools

3.4.2 Goal

Help students know the outside appearance, the scientific name of shellfish species. Furthermore, train students for the ability to observe and skillfully analyze the oyster species.

3.4.3 The process of implementation

Step 1: Learn about Qlone application. Find documents, articles, tutorial videos on how to use the Qlone application.
Step 2: Learn about shellfish collection
Step 3: Select the code of the right size to scan objects of different sizes and shapes.
Step 4: Conduct a scan and complete the collection

3.4.4 Result

With an average time of one scan for a specimen is 5 - 10 minutes. We conducted a single scan of each animal and included 114 collections.

3.4.5. Project analysis

Four elements of STEM during project implementation:
Science: The shellfish collection belongs to the mollusk industry, which is very diverse and mostly lives in the tropics. Characteristics of shellfish types are soft bodies, with limestone shells to support and protect. Depending on the lifestyle, the skin and structure of the body will change.
Technology: First of all, we put the sample to scan in the middle of the AR Mat code. Note that scan light must be a place with a good light source such as sunlight or lights in the room. Then, turn the code into a circle so that the phone can scan the object. The rotation must be slow so as not to lose the small details. Nevertheless, after the first scan, there will be missing objects at the bottom because we can only scan the upper part. Thus it can be seen that if we want the output to have the same result as the real one, one has to scan the second time by placing the object horizontally, to see the bottom of the object. It will be known that the application only scans static objects, does not work with transparent, colorless, and moving objects. A complete scan takes about 10 - 15 minutes.
Engineering: Use Qlone software to Scan 3D models.
Mathematics: Help students improve measurement, scanning, calculation.

Advantages and disadvantages in the project implementation process:

About advantages, it can be seen that the scanned sample is available, the application is free for users and can be posted on a free website for everyone to access. Nevertheless, during the implementation process, there are also certain difficulties, for example, there are several practical models with many parts so scanning does not show details of shellfish. The application is limited to identifying concave surfaces of objects.

4. Empirical Analysis

4.1 A priori analysis

4.1.1 Survey on STEM education and STEM products

a. Content

To be able to quantify the different aspects of STEM product design, we plan to survey 7 questions (from Q1 to Q7) on STEM education and STEM products with the following contents:

Q6A: *In your opinion, what are the benefits of creating STEM products for learners? (Knowledge, skills, attitudes, ...)*
Q6B: *In your opinion, what are the issues to improve the process of creating STEM products?*
Q7A: *In your opinion, what is the average time for the group to create a STEM product?*
Q7B: *In your opinion, how many times should a STEM product be created in a school year?*

b. Analysis

About Q1 and Q2 questions, we want to evaluate the characteristics of the STEM teaching topic, method, and activity. This question is designed according to the 5-step Likert scale to evaluate the quantitative results of the answer. Regarding the Q3 question, we would like to evaluate the product creation in the STEM Education and compare the difficulty level between products. In the Q4 question, we aim to evaluate the STEM skills of people. About the question Q5. This question is rated from 1 to 5, the larger the number, the greater the level of use. In this question, students only evaluate the product they have done. Question Q6 is an open question, we want to understand the benefits of the STEM product creation process and to achieve what is needed to improve. Survey results will be qualitatively analyzed. For question Q7, we aim to evaluate the time factor related to STEM product creation.

Q1: *When studying Mathematics in the direction of creating STEM products, how is your opinion on the following topics?*

Table 1. Q1 question

Content	**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Q1A. Students should use the knowledge and skills in the areas of Science, Technology, Engineering, and Mathematics to solve problems in practice.	1	2	3	4	5
Q1B. Students need practice, creativity to form products.	1	2	3	4	5
Q1C. It is necessary to communicate, cooperate (directly or indirectly) among students in the group to accomplish a common goal.	1	2	3	4	5

Q2: *When studying Mathematics in the direction of creating STEM products, how is your opinion about teaching methods in STEM education?*

Table 2. Q2 question

Content	**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Q2A. Teaching methods in STEM education are learning by doing.	1	2	3	4	5
Q2B. Teaching methods in STEM Education are methods of integrating and integrating the content of 4 fields of Science, Technology, Engineering, and Mathematics to create products.	1	2	3	4	5
Q2C. Teaching activities in STEM education need to stimulate learners to communicate, cooperate, conditionally develop critical thinking and creative thinking.	1	2	3	4	5
Q2D. Teaching activities in STEM education should create excitement and strength for learners.	1	2	3	4	5

Q3: *When studying Mathematics in the direction of the STEM education, how do you rate the creation of STEM products?*

Table 3. Q3 question

Product	**Very difficult to implement**	**Difficult to implement**	**Neutral**	**Easy to implement**	**Very easy to implement**
Q3A. Ball shooting machine	1	2	3	4	5
Q3B. Vacuum cleaner	1	2	3	4	5
Q3C. Decorative lights	1	2	3	4	5

Q4: *When studying STEM-oriented Mathematics, how do you assess yourself about 4 skills: Science, Technology, Engineering, and Mathematics?*

Table 4. Q4 question

Content	Very unconfident	Unconfident	Neutral	Confident	Very confident
Q4A. Science skills	1	2	3	4	5
Q4B. Technology skills	1	2	3	4	5
Q4C. Engineering skills	1	2	3	4	5
Q4D. Mathematics skills	1	2	3	4	5

Q5: *When studying STEM-oriented Mathematics, how do you use Engineering and Technology?*

Table 5. Q5 question

Products	**The level of use of Engineering and Technology (The larger the number, the greater the level of use)**				
Q5A. Ball shooting machine	**1**	**2**	**3**	**4**	**5**
Q5B. Vacuum cleaner	**1**	**2**	**3**	**4**	**5**
Q5C. Decorative lights	**1**	**2**	**3**	**4**	**5**

GRADING MYSELF

Table 6. Q1 question

	Unsatisfactory Effort	Effort Needs Improvement	Satisfactory Effort	Outstanding Effort
Q’1A. I contributed to the team word	3	2	1	0
Q’1B. I exhibited scientific thinking	3	2	1	0
Q’1C. I maintained a positive attitude	3	2	1	0
Q’1D. I completed the building task	3	2	1	0
Q’1E. I reflected on work	3	2	1	0

GRADING MY TEAM

Table 7. Q2 question

	Unsatisfactory Effort	Effort Needs Improvement	Satisfactory Effort	Outstanding Effort
Q'2A. My team worked well together	3	2	1	0
Q'2B. My team displayed problem - solving skills	3	2	1	0
Q'2C. My team had a positive attitude	3	2	1	0
Q'2D. My team completed the building task	3	2	1	0

GRADING BY MY TEACHER

Table 8. Q3 question

	Unsatisfactory Effort	Effort Needs Improvement	Satisfactory Effort	Outstanding Effort
Q’3A. Student cooperated with team	3	2	1	0
Q’3B. Student exhibited scientific thinking	3	2	1	0
Q’3C. Student maintained a positive attitude	3	2	1	0
Q’3D. Team completed the building task	3	2	1	0
Q’3E. Student reflected on work	3	2	1	0

4.1.2 Self-assessment table during the STEM product creation process

a. Content

To further analyze the process of forming the STEM products, a rubric is designed with 3 parts: grading myself, grading my team, and grading by my teacher.

b. Analysis

The self-assessment table is a clear scoring tool for the performance of a team member or part of a job (See Karkehabadi (2013)). To evaluate teamwork skills, creative thinking, the level of personal impact on work, and the contribution to the group and the working attitude, we built a rubric according to Sarah (2015). These questions are designed according to a scale of 4 steps to evaluate the quantitative results of the answers. We encode the following points: Unsatisfactory Effort: 0 point, Effort Needs Improvement: 1 point, Satisfactory Effort: 2 points, and Outstanding Effort: 3 points. In question Q'3, only students who perform at the pilot test have their students guide the assessment.

4.2 A Posteriori Analysis

4.2.1 Statistics of survey votes

The questionnaire from Q1 to Q7 was sent to 39 students of class 11A1 and 37 students selected to participate in the contest "Design STEM Product" (coming from seven classes: 10A1, 10A2, 10B1, 10B2, 11A2, 11B1, and 11B2). Hence the total number of votes is 76 votes. The quantitative analysis results of the survey are presented in the next section.

4.2.2 Results and analysis

a. Characteristics of the STEM education theme

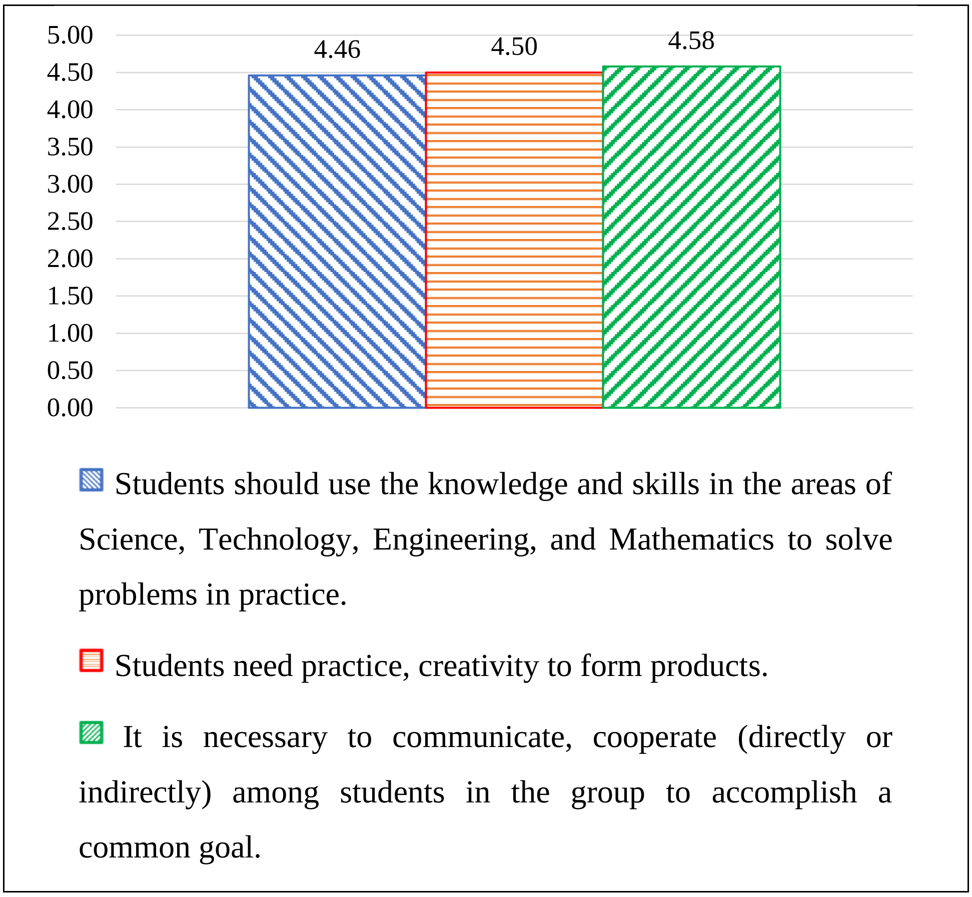


Diagram 2

Characteristics of the STEM Education theme

Q1A. The average 4.46 indicates that students agree with the idea that "Students should apply the knowledge and skills in the areas of Science, Technology, Engineering, and Mathematics to solve practical problems". This demonstrates that the empirical model has contributed to raising students' awareness of STEM and STEM education. From there, every student can find a connection between Science subjects, especially Mathematics with daily life.

Q1B. The average of 4.50 indicates that students consent to the idea that "Students need practice and creativity to form products". Students have been more focused on giving birth to applied products to real life in the learning process - an important goal of the STEM education.
Q1C. The average 4.58 indicates that students' consensus with the idea of "Communicating, collaborating (directly or indirectly) among students in the group to accomplish a common goal is necessary". Students have paid more attention to improving communication and cooperation skills.

It has been seen that the median value is 4, which is higher than the theoretical average value of 3, indicating that the trend of opinion is tilted towards the positive. It can be observed from diagram 3 that, this diagram is an "almost" equilateral triangle, indicating that all three pillars of the STEM education are valued by students almost equally.

Q2A. The average of 4.18 indicates that students relatively consensus with the idea "Teaching methods in STEM education are teaching through practice". Thereby, each student raises awareness about actively participating in activities, practices, experiences, and knowledge acquisition.
Q2B. The average of 4.24 indicates that students agree very high with the idea that "Teaching methods in the STEM education are methods of integrating the content of 4 fields of Science, Technology, Engineering, and Mathematics to create products". The above results show that students are interested in integrated learning, adapting to current educational trends.
Q2C. The average of 4.36 indicates that students consent very highly with the idea that "Teaching activities in STEM education should stimulate learners to communicate, cooperate, and conditionally develop critical thinking and creative thinking". This shows that through STEM projects, students have become more positive and active.

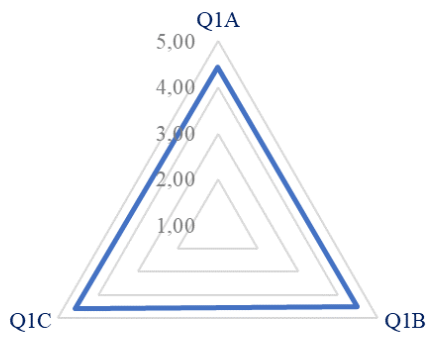


Diagram 3

Relationship between 3 characteristics

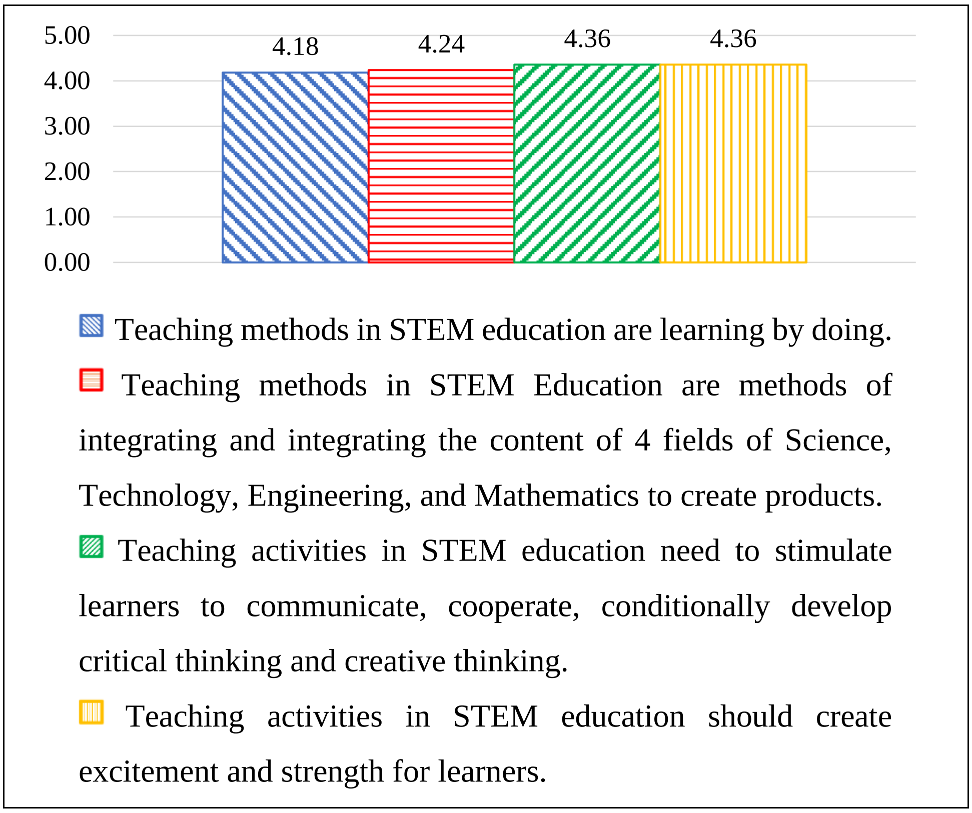


Diagram 4

Characteristics of teaching methods and STEM educational activities

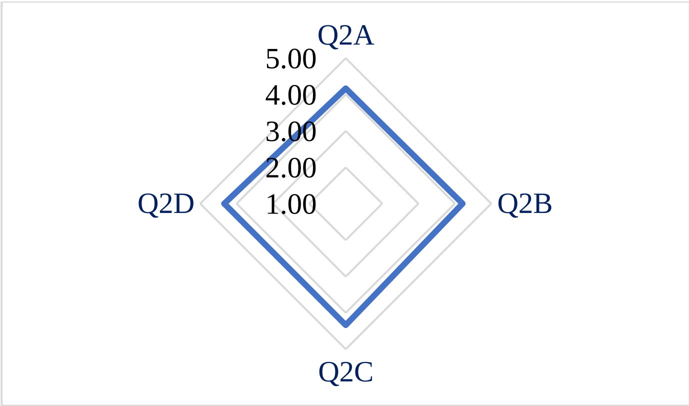


Diagram 5

The relationship between 4 characteristics of STEM method and educational activities

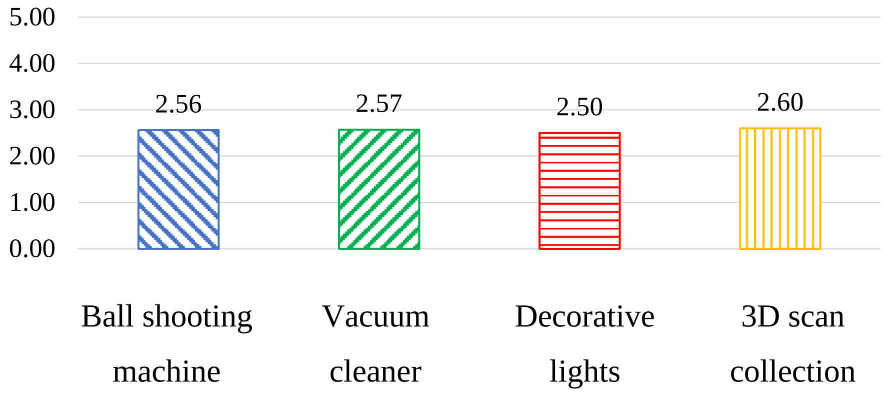


Diagram 6

Evaluate the level (easy - hard) of product creation in STEM education

Q2D. The average level of 4.36 indicates that students agree very much with the idea "Teaching activities in STEM education should create excitement and strength for learners". Students have felt appealing, attractive for STEM projects. Thereby, each student tries to cultivate the skills needed to complete better projects.

It can be seen that the median value is 4 and 5, which is higher than the theoretical average value of 3, indicating that the opinion trend is biased towards the positive. It can be observed from diagram 5 that, this diagram is an "almost" regular quadrilateral, demonstrating that teaching methods and activities in STEM education are valued equally.

First, with the above data and the average value of 4 products is 2.56, between the "difficult to implement" level and the "neutral" level, this is because the students have not had much access to STEM, no experience in creating products from interdisciplinary knowledge. The evaluation value of the ball shooting machine project with a score of 2.56, The implementation of the machine project has problems with friction between parts, this may be due to the understanding and approach to materials of students are limited. Besides, although most students are equipped with Mathematics knowledge in the curriculum very well, the application into practice, calculation in the shooting process to hit the desired goal has made it difficult for students.

The evaluation value of the vacuum cleaner project with a score of 2.57, the implementation of the project is difficult to find a rechargeable and sufficient voltage source. In meanwhile, the evaluation value of decorative lights projects with a score of 2.50, the implementation of decorative lights is difficult in ion transformation of solutions that generate an electric current with a low voltage. For the final project, the evaluation value of the 3D scan collection project with a score of 2.60, the implementation of 3D model scanning is quite favorable, but it is still difficult to find actual models to scan.

The evaluation score on the confidence level of the four skills is close to the "Neutral" level, this is partly because the learners are not well aware of these skills and have not had much access to activities, competitions, projects that use those skills.

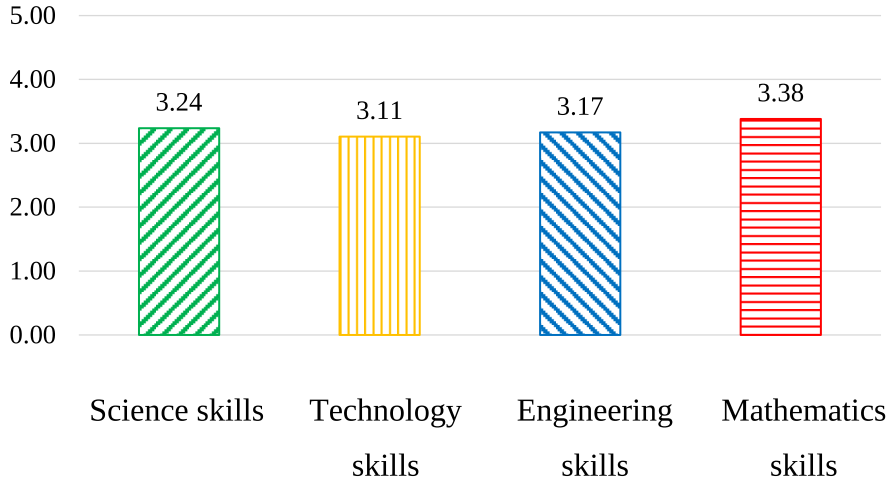


Diagram 7

Evaluation of learner's STEM skills

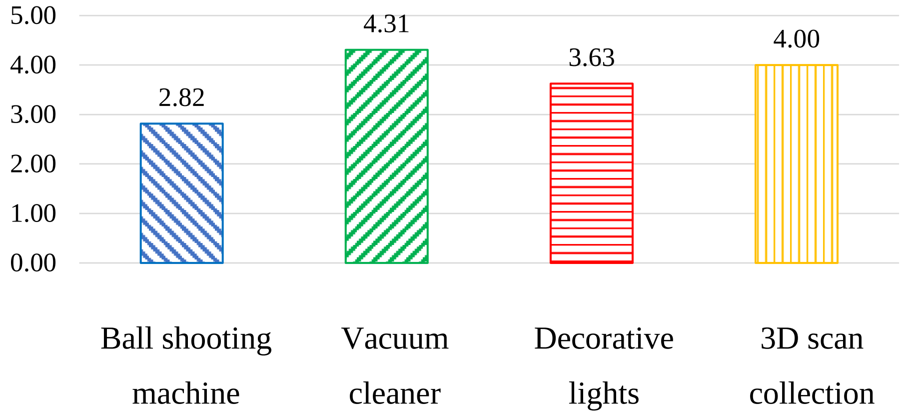
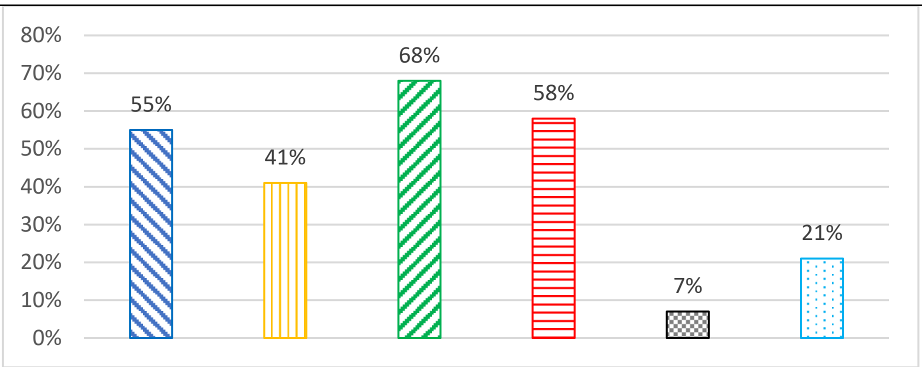


Diagram 8

Evaluation of the use of Engineering and Technology



Consolidate and supplement knowledge.

Train creative thinking, create excitement for students.

Develop teamwork skills, increase solidarity.

Enhance the ability to apply knowledge to solve problems in practice.

Skill and technical development.

Train positive, persistent, and responsible.

Diagram 9

Benefits of implementing STEM products

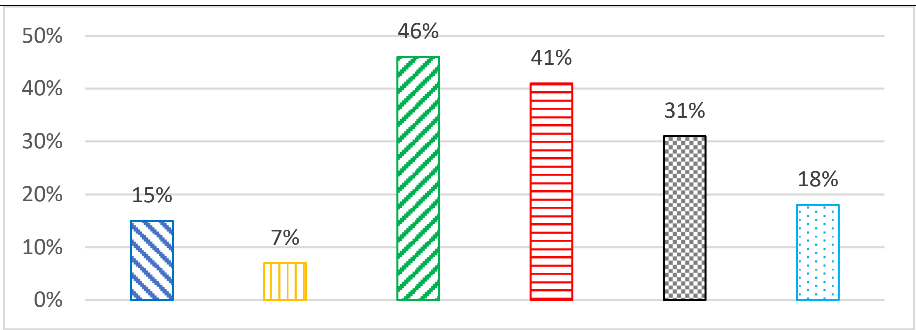
Products that are evaluated, it can be seen that the use of Engineering and Technology at the level “Neutral”. Nevertheless, the evaluation value of the ball shooting project is still low, indicating that because of the fact that the ball shooting machine is due to the force of the operator, the engines are not integrated.

More than half of the survey questionnaires indicate that the benefits of implementing STEM projects are to consolidate and supplement knowledge, increase the ability to apply the knowledge learned to solve problems in practice. This is one of the characteristics of the STEM education theme. Another characteristic that is indispensable in education is teamwork skills, the development of this skill during the implementation of the STEM project was given the most with 68%.

Besides, in the process of project implementation, the ability to think creatively and interest in design is essential to create a product of new nature and quality, so "train creative thinking, creating excitement for students” was given by 41% of the votes. Moreover, students also practice positive, persistent, and responsible in the collective activities.

It has been seen that, increasing students' understanding of scientific knowledge, enhancing collaboration, as well as improving creative thinking ability is essential for implementing STEM projects. An important element of project implementation is an experience, students need to organize activities to create STEM products to develop themselves more, to be able to meet the requirements of the industrial age 4.0. In addition, the support of teachers, support of equipment, tools, and comfort in the design space will create favorable conditions for students to implement their ideas to create produce STEM products for practical life.

Through the implementation of the STEM project, according to the survey, the average time for the group to create a STEM product is 23 working hours and the number of times to organize STEM project activities is 2.3 times. With this result, the organization of implementing STEM projects should be organized twice per year, this means that each semester is held once and the time for each project is about 3 weeks. That means that every week, students spend about 3 sessions and about 3 hours each.



Increase understanding of scientific knowledge.

Improve creative thinking ability.

Enhance the level of cooperation of the group.

Need to improve and practice the project implementation experience.

Favorable facilities.

There are instructors.

Diagram 10

Things to improve for the STEM products

Content	Average score
“I contributed to the teamwork”	2,17
“I exhibited scientific thinking”	1,79
“I maintained a positive attitude”	2,35
“I completed the building task”	2,10
“I reflected on work”	2,00

Table 9

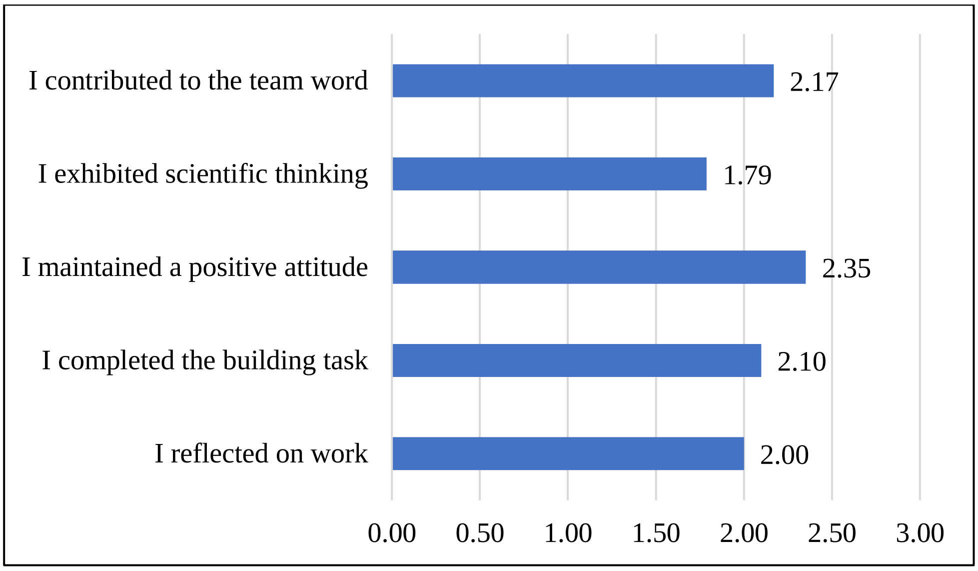


Diagram 11

Individual self-assessment results

4.2.4 Analyzing self-assessment results in the process of creating STEM products

Because class 11A1 was the only class with 100% of the participants participating in the experiment and designed all four research products, the rubric evaluation of the progress was sent to 39 members of this class. The analytical results are presented in the next section.

Group activities have been organized effectively when promoting the teamwork skills of each individual. Each individual has made positive contributions to accomplishing the assigned group tasks, expressed as indicators of group contribution to work (2.17), positive attitude when working in groups (2.35), completing the task of the group (2.10) and each individual's influence on the group's overall work (2.00) is above the average (1.50).

However, organized group activities have not promoted the scientific thinking of each individual, this is reflected in the index of scientific thinking development (1.79) lower than the remaining indexes and lower than the average value (2.09). The index of maintaining the highest positive attitude (2.35) shows that group activities have created excitement in the learning of each individual.

Indicators of group work level, positive attitude, completion of the group's design tasks are not much different from individuals. This shows the results of the group as a result of each individual in the group, the group wants to achieve good results, each member must make efforts. According to the above data, the group's problem-solving skills have the lowest score, this is because the group has not had many opportunities to solve problems. This shows that STEM projects for students need more organization.

Teachers' indicators are higher than student scores and group assessment scores. That shows the activities and attitudes of students who have initially met the teachers' requirements. On the other hand, teachers want to encourage students' learning, creativity, self-discovery, and knowledge-based skills to evaluate higher indicators. Nevertheless, the index evaluates the level of work completion quite low. Because this is the first time to conduct group activities on STEM projects, the products created have not been completed, there are many shortcomings.

Content	Average score
“My team worked well together”	2,15
“My team displayed problem - solving skills”	2,11
“My team had a positive attitude”	2,35
“My team completed the building task”	2,04

Table 10

Results of team self-assessment

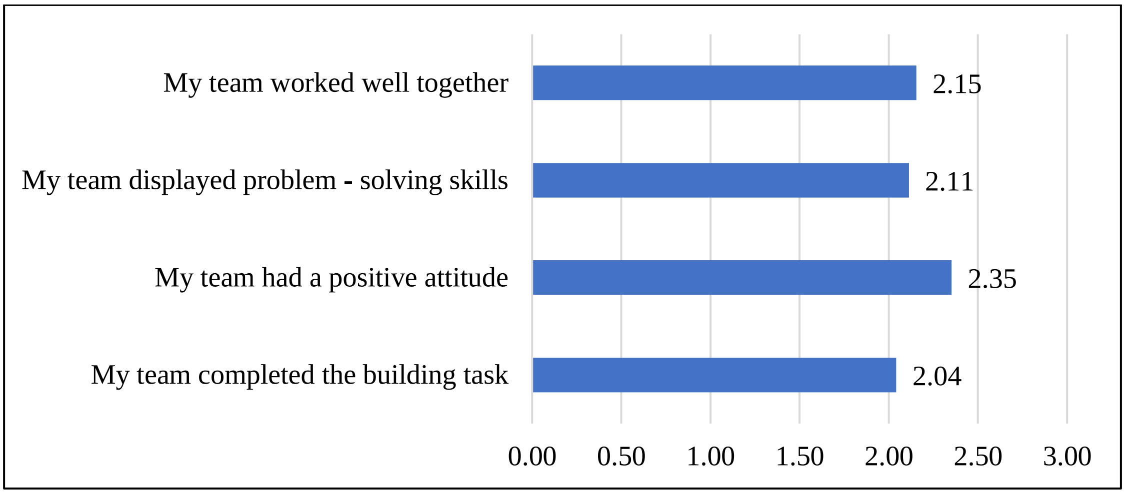


Diagram 12

Results of team self-assessment

Content	Average score
“Student cooperated with team”	2,85
“Student exhibited scientific thinking”	2,62
“Student maintained a positive attitude”	2,91
“Team completed the building task”	2,18
“Student reflected on work”	2,56

Table 11

Evaluation results of instructors

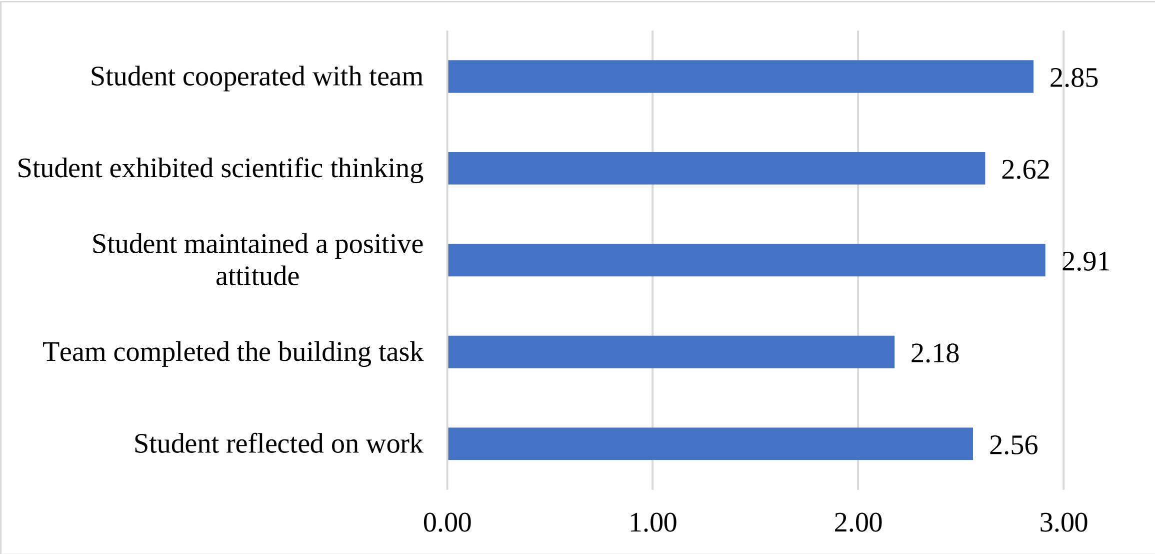


Diagram 13

Evaluation results of instructors

5. Concluding Remarks

This research follows Tuan et al. (2019) and others to apply the STEMTech model to create STEM products in the context of High Schools in Vietnam. We design the survey questionnaires and distribute the questionnaires to respondents to get our survey done. We then carry out a quantitative analysis to evaluate rubric and find positive feedback from learners, implying that at both High School and University, the STEMTech model has shown encouraging results.

This research also proposes the four products developed in our paper can be used in many different directions, including to use 3D printing technology to make the cover for the vacuum cleaner, to apply the ball machine for training in tennis, manufacture decorative lights into night lamps, 3D scanning technology as a collection of rare and precious animals. These real-life applications of these STEM products once again show the suitability, vitality, and potential of applying the STEMTech model when it comes to teaching, including High Schools and Universities.

Nevertheless, the organization of implementing the STEM model faces some difficulties. For example, students may have no experience in creating any STEM product, not familiar with applying the STEM model to solve real problems, no design space at schools, and not enough support of equipment and tools. Although many challenges have to overcome, with the advantages and outstanding opportunities from using the STEM education and from the industrial revolution 4.0, the STEM model has a lot of potentials to develop and replicate at many high schools and universities in Vietnam and other countries.

From the perspective of Decision Science, the research also shows that the choice of the STEMTech model is a good idea and is suitable in the context of teaching today. Readers can refer to other topics in Decision Sciences, for example, Finance (Wong, 2006; Ly et al. 2019a,b; Batai et al., 2017, Truong et al. 2019, Suu et al. 2020), capital (Thompson and Wong, 1991, 1996; Wong and Chan, 2004; Lam et al., 2010, 2012; Chang et al., 2017), Statistics (Mahmoudi et al. 2020 a,b,c,d,e,d, Pho et al. 2018, 2019a, b, c, 2020 a, b, Tian et al. 2019, Tuan et al. 2018, 2019a,b,c, Li et al. 2020), and logistics (Moslehpour et al., 2018; Tien et al., 2019). There are many other topics can be found in Decision Sciences, readers may refer to Chang, et al., 2016, 2017, 2018, 2020), Fu et al. 2020, Maleki et al. 2020, Nguyen et al. 2020, Seyed et al. 2020, Szeto et al. 2020, Trung et al. 2020, Wang et al. 2020, and Zhou et al. 2020, Hau et al 2019, 2020 for more information.

References

Andrée, M. & Hansson, L. (2013). Marketing the 'Broad Line': Invitations to STEM education in a Swedish recruitment campaign. *International Journal of Science Education*, 35 (1), pages 147-166.

Barron, B. J., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., & Bransford, J. D. (1998). Doing with understanding: Lessons from research on problem-and project-based learning. *Journal of the learning sciences*, *7*(3-4), 271-311.

Basham, J. D., Israel, M. & Maynard, K. (2010). An Ecological Model of STEM Education: Operationalizing STEM for All. *Journal of Special Education Technology*, 25(3), pages 9-19.

Batai, A., Chu, A.M.Y., Lv, Z.H., & Wong, W.K. (2017). China's impact on Mongolian Exchange Rate, *Journal of Management Information and Decision Sciences*, 20(1), 1-22.

Bissaker, K. (2014). Transforming STEM Education in an Innovative Australian School: The Role of Teachers' and Academics' Professional Partnerships. *Theory into Practice,* 53 (1), pages 55-63.

Canessa, E., Fonda, C., & Zennaro, M. Low Cost 3D Printing for Science, Education & Sustainable Development (ICTP—The Abdus Salam International Centre for Theoretical Physics 2013 ICTP Science Dissemination Unit, 2013).

Capraro, R. M., Capraro, M. M., & Morgan, J. R. (Eds.). (2013). *STEM project-based learning: An integrated science, technology, engineering, and mathematics (STEM) approach*. Springer Science & Business Media.

Chang, C.-L., McAleer, M., Wong, W.K. 2016, Management science, economics and finance: A connection. *International Journal of Economics and Management Sciences*, 5(4), 1-19.

Chang, C.L., McAleer, M., Wong, W.K. 2017. Management Information, Decision Sciences, and Financial Economics: A Connection, *Journal of Management Information and Decision Sciences*, 20, 1-19.

Chang, C.-L., McAleer, M., Wong, W.K. 2018. Big Data, Computational Science, Economics, Finance, Marketing, Management, and Psychology: Connections. *Journal of Risk and Financial Management* 11(1): 15.

Chang, C.-L., McAleer, M., Wong, W.K. 2020. Risk and Financial Management of COVID-19 in Business, Economics, and Finance. *Journal of Risk and Financial Management*, 13(5), 102; https://doi.org/10.3390/jrfm13050102

Chen, Y., & Chang, C. C. (2018). The Impact of an Integrated Robotics STEM Course with a Sailboat Topic on High School Students' Perceptions of Integrative STEM, Interest, and Career Orientation. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(12), 1614.

Debeş, G. (2018). Effects of STEM education seminars on teachers in the schools of North Cyprus. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(12), 1-7.

Fu, W., Parvin, H., Mahmoudi, M. R., Tuan, B. A., & Pho, K. H. (2020). A linear space adjustment by mapping data into an intermediate space and keeping low level data structures. *Journal of Experimental & Theoretical Artificial Intelligence*, 1-21.

Hau, N. H., Tuan, B. A., Giang, T. T., & Wong, W-K. (2020). Application of assessment in decision sciences: a study on the assessment of students' mathematical achievement in Vietnam high schools. *Journal of Management Information and Decision Sciences*, 23(2), 86-111.

Hau, N. H., Tuan, B. A., Thao, T. T. T., & Wong, W-K. (2019). Teaching mathematics by practical decision modeling in Vietnam high schools to serve the fourth industrial revolution. *Journal of Management Information and Decision Sciences*, 22(4), 444-461.

Karkehabadi, S. (2013). Using rubrics to measure and enhance student performance.

Kuenzi, J. J. (2008). Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action.

Kuenzi, J. J., Matthews, C. M., & Mangan, B. F. (2006, July). Science, technology, engineering, and mathematics (STEM) education issues and legislative options. Library of Congress Washington DC Congressional research service.

Lam, K., Liu, T. S., Wong, W. K. (2012). A New Pseudo Bayesian Model with Implications to Financial Anomalies and Investors' Behaviors. *Journal of Behavioral Finance*, 13(2), 93-107.

Li, G., Mahmoudi, M. R., Qasem, S. N., Tuan, B. A., & Pho, K. H. Cluster ensemble of valid small clusters. *Journal of Intelligent & Fuzzy Systems*, (Preprint), 1-18.

Lin, K. Y., Hsiao, H. S., Chang, Y. S., Chien, Y. H., & Wu, Y. T. (2018). The effectiveness of using 3D printing technology in STEM project-based learning activities. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*, 12.

Ly, S., Pho, K.H., Ly, S., Wong, W.K. 2019a, Determining Distribution for the Product of Random Variables by Using Copulas, *Risks*, *7*(1), 23; https://doi.org/10.3390/risks7010023.

Ly, S., Pho, K.H., Ly, S., Wong, W.K. 2019b, Determining Distribution for the Quotients of Dependent and Independent Random Variables by Using Copulas, J*ournal of Risk and Financial Management*, *12*, 42. https://doi.org/10.3390/jrfm12010042.

Mahmoudi, M. R., Baleanu, D., Tuan, B. A., & Pho, K.H.(2020a). A Novel Method to Detect Almost Cyclostationary Structure. *Alexandria Engineering Journal*. (In press).

Mahmoudi, M. R., Heydari, M. H., Avazzadeh, Z., & Pho, K. H. (2020b). Goodness of fit test for almost cyclostationary processes. *Digital Signal Processing*, 96, 102597.

Mahmoudi, M. R., Heydari, M. H., & Pho, K. H. (2020c). Fuzzy clustering to classify several regression models with fractional Brownian motion errors. *Alexandria Engineering Journal*.

Mahmoudi, M. R., Maleki, M., Baleanu, D., Nguyen, V. T., & Pho, K. H. (2020d). A Bayesian Approach to Heavy-Tailed Finite Mixture Autoregressive Models. *Symmetry*, 12(6), 929.

Mahmoudi, M. R., Mohsen, M., Baleanu, D., Kirill, B., & Pho, K.H.* (2020e). On Comparing and Clustering the Spectral Densities of Several Almost Cyclostationary Processes. *Alexandria Engineering Journal*. (In press).

Mahmoudi, M. R., Nasirzadeh, R., Baleanu, D., & Pho, K. H. (2020f). The Properties of a Decile-Based Statistic to Measure Symmetry and Asymmetry. *Symmetry*, 12(2), 296.

Maleki, M., Mahmoudi, M. R., Wraith, D., & Pho, K. H. (2020). Time series modelling to forecast the confirmed and recovered cases of COVID-19. *Travel Medicine and Infectious Disease*, 101742.

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). STEM: country comparisons: international comparisons of science, technology, engineering and mathematics (STEM) education. Final report.

Moslehpour, M., Bilgicli, I., Wong, W.K., Hua-Le, Q.-X. (2018). Meeting the Agricultural Logistics Requirements of Accommodation Enterprises in Sakarya, Turkey, *Journal of Management Information and Decision Sciences*, 21(1).

Nguyen, T. T., Trinh, T. P. T., Ngo, H. T. V., Hoang, N. A., Tran, T., Pham, H. H., & Bui, V. N. (2020). Realistic Mathematics Education in Vietnam: Recent Policies and Practices. *International Journal of Education and Practice*, 8(1), 57-71.

Osman, K., & Saat, R. M. (2014). Science technology, engineering and mathematics (STEM) education in Malaysia. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(3), 153-154.

Pitt, J. (2009). Blurring the boundaries–STEM education and education for sustainable development. *Design and Technology Education: An International Journal*, *14*(1).

Pho, K. H., & Nguyen, V. T. (2018). Comparison of Newton-Raphson algorithm and Maxlik function. *Journal of Advanced Engineering and Computation*, 2(4), 281-292.

Pho, K. H., Ho, T.D.C., Tran, T.K., & Wong, W.K. (2019a). Moment Generating Function, Expectation and Variance of Ubiquitous Distributions with Applications in Decision Sciences: A Review. *Advances in Decision Sciences*, 23(2), 1-85.

Pho, K. H., Ly, S., Ly, S., & Lukusa, T. M. (2019b). Comparison among Akaike Information Criterion, Bayesian Information Criterion and Vuong's test in Model Selection: A Case Study of Violated Speed Regulation in Taiwan. *Journal of Advanced Engineering and Computation*, 3(1), 293-303.

Pho, K. H., Tran, T.K., Ho, T.D.C., & Wong, W.K. (2019c). Optimal solution techniques in decision sciences: A review. *Advances in Decision Sciences*, 23(1), 1-47.

Pho, K. H., Heydari, M. H., Tuan, B. A., & Mahmoudi, M. R. (2020a). Numerical study of nonlinear 2D optimal control problems with multi-term variable-order fractional derivatives in the Atangana-Baleanu-Caputo sense. *Chaos, Solitons & Fractals*, 134, 109695.

Pho, K. H., Sarshad, M., Alizadeh, P., & Mahmoudi, M. R. (2020b). Soil carbon pool changes following semi-arid lands planting programs. *CATENA*, 191, 104563.

Sanders, M. (2009). Integrative STEM education: primer. *The Technology Teacher*, *68*(4), 20-26.

Sarah (2015). How to Grade STEM Projects - More Than a Worksheet.

Schwab, K. (2017). *The fourth industrial revolution*. Currency.

Seyed, M.J.J., Iman, R.V., Han, W.P., & Pho, K.H. (2020). Research Trends on Big Data Domain Using Text Mining Algorithms. *Digital Scholarship in the Humanities*. (In press).

Suu, N. D., Luu, T. Q., Pho, K. H., & McAleer, M. (2020). Net Interest Marginof Commercial Banks in Vietnam. *Advances in Decision Sciences,* 24(1), 1-27.

Szeto, P. M., Parvin, H., Mahmoudi, M. R., Tuan, B. A., & Pho, K. H. Deep neural network as deep feature learner. *Journal of Intelligent & Fuzzy Systems*, (Preprint), 1-15.

Thompson, H.E., Wong, W.K. (1991). On the unavoidability of ``unscientific'' judgement in estimating the cost of capital. *Managerial and Decision Economics*, 12, 27-42.

Thompson, H.E., Wong, W.K. (1996). Revisiting 'Dividend Yield Plus Growth' and Its Applicability, *Engineering Economist*, 41(2), 123-147.

Tian, Y., Pho, K.H. (2019). A Statistical View to Study the Aphorisms in Nahj al Balaghah. *Digital Scholarship in the Humanities*. (In press).

Trung, T., & Nguyen, T. T. (2020). Mathematics Teaching in Vietnam in the Context of Technological Advancement and the Need of Connecting to the Real World. *International Journal of Learning, Teaching and Educational Research,* 19(3), 255-275.

Truong, B. C., Pho, K. H., Nguyen, V. B., Tuan, B. A., & Wong, W. K. (2019). Graph Theory and Environmental Algorithmic Solutions to Assign Vehicles: Application to Garbage Collection in Vietnam. *Advances in Decision Sciences*, 23(3), 1-35.

Tsupros, N., Kohler, R., & Hallinen, J. (2009). STEM education: A project to identify the missing components. Intermediate Unit 1: Center for STEM Education and Leonard Gelfand Center for Service Learning and Outreach.

Tuan, B. A. & Ho, T. D. C. (2018). A Preliminary Research of Upgrading Mathematics Teaching on the Basis of Research-based Learning in Vietnamese High Schools. *Vietnam Journal of Education*, 5, 125-130.

Tuan, B. A., McAleer, M., Dang, N. T. T., & Pho, K. H. (2019a). Developing Formulas for Quick Calculation of Polyhedron Volume in Spatial Geometry: Application to Vietnam. Available at SSRN 3474168.

Tuan, B. A., Pho, K. H., Huy, L. M., & Wong, W. K. (2019b). STEMTECH MODEL IN ASEAN UNIVERSITIES: AN EMPIRICAL RESEARCH AT CAN THO UNIVERSITY. *Journal of Management Information and Decision Sciences*, *22*(2), 107-127.

Tuan, B. A., Pudikova, G.N., Mahmoudi, M.R., & Pho, K.H.(2019c). Statistical approaches in literature: Comparing and clustering the alternatives of love in Divan of Hafiz. *Digital Scholarship in the Humanities*. (In press).

Wang, Y., Garjami, J., Tsvetkova, M., Huu Hau, N., & Pho, K. H. (2020). Statistical approaches in literature: An application of principal component analysis and factor analysis to analyze the different arrangements about the Quran's Suras. *Digital Scholarship in the Humanities*. (In press).

Wong, W.K. (2006), Stochastic Dominance Theory for Location-Scale Family, Journal of Applied Mathematics and Decision Sciences, *Advances in Decision Sciences*, 2006, 1-10.

Wong, W.K., R. Chan (2004). On the estimation of cost of capital and its reliability, Quantitative Finance, 4(3), 365 - 372.

Zhao, W. (2018). Retraction of STEM Education in English of Early Childhood in China. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(1).

Zhou, R., Mahmoudi, M. R., Mohammed, S. N. Q., & Pho, K. H. (2020). Testing the equality of the spectral densities of several uncorrelated almost cyclostationary processes. *Alexandria Engineering Journal*. (In press).

Zendler, A., Seitz, C., & Klaudt, D. (2018). Instructional Methods in STEM Education: A Cross-contextual Study. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(7), 2969-2986.

Edward M. Reeve (2015). Science, Technology, Engineering and Mathematics (STEM) Education is here to stay. Utah State University. 98 pages. Accessed on: 24/04/2018
Available from: http://www.stemedthailand.org/wp-content/uploads/2015/08/STEM-Education-is-here-to-stay.pdf

Ozel, S (2013). Who, when, and where. In R. M. Capraro, M. M. Capraro & J. Moran (Eds.), STEM Project-based learning: An integrated science technology engineering and mathematics (STEM) approach. Rotterdam, Netherlands: Sense. 41-46.