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Message from the EEAAT President

Assoc. Prof. Dr.Athikom Roeksabutr
President Electrical Engineering Academic Association (Thailand)

Welcome to iSTEM-Ed 2022. On behalf of the Electrical Engineering Academic Association (Thailand), EEAAT, it is our pleasure to co-host the 2022 International STEM Education Conference (iSTEM-Ed 2022) with Rajamangala University of Technology Phra Nakhon. Since the first debut of iSTEM-Ed 2016 in Pattaya, it has moved around Thailand to Chiangmai (iSTEM-Ed 2017), Bangkok (iSTEM-Ed 2018) Nakhon Phanom (iSTEM-Ed 2019), Phranakorn Si Ayutthaya (iSTEM-Ed 2020), and back to Pattaya Chonburi (iSTEM-Ed 2021) last year. This year, the 7th International STEM Education Conference (iSTEM-Ed 2022) is arranged in Sukhothai, where is traditionally known as "the first Thai kingdom" in Thai historiography. We hope the conference will provide both academic and friendship atmosphere for educators, researchers, and academia to exchange fruitful knowledge in STEM education, which mainly includes Science, Technology, Engineering Mathematics and additional Art.

We would like to express deeply appreciation to all participants, conference committee, and organizing team to make such a wonderful conference and also special thanks to all authors and reviewers who have made great contribution on STEM education. In addition, many thanks

to all technical supporters as IEEE Education Society, IEEE Thailand Section, IEEE Education Society Thailand Chapter and the institute for the Promotion of Teaching Science and Technology (IPST).

Last but not least, we wish everyone who join iSTEM-Ed 2022 found valuable time and good opportunity to learn and exchange knowledge and experiences in STEM education during the conference.

Welcome message from

the President of RMUTP

Dr. Natworapol Rachsiriwatcharabul
President of Rajamangala University of Technology Phra Nakhon

On behalf of the Organizing Committee, it is my great pleasure to welcome you all to the 7th international STEM Education Conference 2022 (iSTEM-Ed) in Sukhothai, Thailand.

The iSTEM-Ed 2022 Conference is organized by Rajamangala University of Technology Phra Nakhon and faculty of industrial education RMUTP in collaboration with the Electrical Engineering Academic Association (Thailand) (EEAAT) under the theme STEM Education for Sustainable Development and Lifelong Learning. The organizing committee is intended to connect more than 200 academics, researchers, educators, scientists, engineers, technologists, and related careers to share their experiences, knowledge, and learning and teaching techniques in Science, Technology, Engineering, and Mathematics (STEM) and build a bridge for future collaborative projects that will affect the quality development of our lives at national and international levels.

We are truly honored those two conspicuous professors from the United States and Taiwan for representing on-site keynote addresses. Professor Jay K. Rosengard, Director of the

Harvard University Thai Studies Program, Ash Center for Democratic Governance and Innovation, Harvard Kennedy School, United States, will give a lecture entitled "Public Policy, Economics, and Higher education". Professor Hang Lee, Department of Business Administration, College of Management, National Kaohsiung University of Science and Technology, Taiwan, will share her expertise on "Technology Innovation and Education Reform". Furthermore, according to the present circumstance of COVID-19, we also invite Professor Mattias Lindahl, an outstanding professor from Environmental Technology and Management, Department of Management and Engineering, Linköping University, Sweden, to deliver the keynote addresses in the online session on the topic "A sustainable future: Eco-design and Product Service Systems (PSS)".

We offer special thanks to EEAAT, IEEE Thailand Section, IPST, The International Steering Committees, Technical Program Committee, and Organizing Committee Members for their dedication and support in organizing this successful event. We would also thank our honorable keynote speakers, including session chairs and presenters, for their willingness and professional performance. We wish you all great success, and we appreciate your participation in the iSTEM-ED 2022 Conference.

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A Study on Bhutanese IT Engineering Students' Perceptions of Plagiarism

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Abstract

The purpose of this research is to study the perceptions on plagiarism of students from Royal University of Bhutan, College of Science and Technology**.** This research covers the forms of plagiarism that students practice and the factors that prompt them to practice plagiarism**.** Among all factors, the relationship between teacher and student seems to be under the limelight where it can clearly be seen in what ways the relationship can influence such practices**.** It is seen that if a teacher is lenient and does not check the plagiarism in the work done by students, this tends to encourage them to perform more plagiarism**.** On the other hand, if a teacher is strict and monitors the work of students then it discourages students from practising plagiarism**.** The students were

equally selected from the first year and the final year. This paper depicts how the students' perceptions of plagiarism changed over the years. There can be seen a drastic change in the level of confidence and though all of the students admitted to practising plagiarism, the reasons to do this seem to be different.

Keywords—plagiarism, semi-structured interviews, academic offence

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***Abstract*—The purpose of this research is to study the perceptions on plagiarism of students from Royal University of Bhutan, College of Science and Technology. This research covers the forms of plagiarism that students practice and the factors that prompt them to practice plagiarism. Among all factors, the relationship between teacher and student seems to be under the limelight where it can clearly be seen in what ways the relationship can influence such practices. It is seen that if a teacher is lenient and does not check the plagiarism in the work done by students, this tends to encourage them to perform more plagiarism. On the other hand, if a teacher is strict and monitors the work of students then it discourages students from practising plagiarism. The students were equally selected from the first year and the final year. This paper depicts how the students' perceptions of plagiarism changed over the years. There can be seen a drastic change in the level of confidence and though all of the students admitted to practising plagiarism, the reasons to do this seem to be different.**

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I. Introduction

Bhutan is a tiny Himalayan country with rich culture and tradition. After being self-isolated until 1961, Bhutan is undergoing rapid development while upholding its tradition and embracing modern culture. Before the era of the internet, plagiarism was tiresome for students who would most likely copy from a book, encyclopedia, or newspaper [1]. It was quite a task to access the information but with the excessive and easy use of the internet nowadays, plagiarism became a serious issue. Plagiarism is commonly defined as copying someone's work and presenting it as yours, stealing someone's idea, copying something, and not giving credit to the right person [2]. In academic education, some students plagiarise without having an intention of doing so and some do it knowing that it might be something to be prevented. Plagiarism is taken seriously in academics. In Bhutan, plagiarism is a serious academic offence and, if proven against a participant, may result in disqualification for any marks or academic award [3].

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The research was carried out in order to see how students perceive plagiarism. The study includes revealing the forms that they practiced, factors that encouraged them to practice plagiarism, and the relationship between teacher and student regarding plagiarism. The differences in perceptions of plagiarism between the first year and final year students were also studied. This study aims to offer insights on how Bhutanese engineering students perceive plagiarism and their motives for doing it. The research can also be a helpful aid to future researchers who want to learn more about students' plagiarism in Bhutan and can help colleges and teachers to work on reducing plagiarism.

Two of the authors are students at the College of Science and Technology at the Royal University of Bhutan currently studying at Uppsala University, Sweden. One is an international master's student at Uppsala University and one is a researcher and teacher at Uppsala University.

II. Literature Review

Several studies indicate that the behaviour of teachers plays a major role in students practising plagiarism. The students responded that the seriousness of their work depended on their teachers. The lack of emphasis on plagiarism from the teachers is one of the reasons why students continue plagiarizing, in a study from a University of New England, USA [4]. One study done in a regional college in the western USA on the student-teacher relationship's effect on academic integrity showed that students who admitted doing plagiarism generally disliked teachers' behaviour compared to students who did not admit to having plagiarised [5]. A study conducted in Illinois showed that the teacher-student relationship is impacted by students' perceptions of the plagiarism detection program which hinders the learning environment and develops futile relationships [6]. Another study conducted in the UK found that norms and ethical value systems determine not just whether students find plagiarism unethical, but also whether they allow cheating and collaboration, depending on educational discipline, and teacher education against informatics [7].

There are different reasons for students to practice plagiarism. Lack of practice for correct referencing was found to be the main reason for students to plagiarise in research done at an Australian university [8]. A study done in Malaysia also showed that lack of understanding, lack of awareness, and lack of competence resulted in students indulging in plagiarising [9]. In a study done at Uppsala University, Sweden where master's students were interviewed. It was found that students considered plagiarism to be a collaboration [10].

A study carried out as a comparison of German and Slovene students revealed that the fundamental cause behind plagiarism is ready to access to information communication technology and the Internet. Most of the findings were the same except for minor differences like in Slovenia, the direct teaching about plagiarism had greater influence than in Germany. The focus in Germany was on the establishment and dissemination of an ethical code, as well as the training of students to cope with pressure [11]. Research conducted in Spain concluded that poor working conditions and unfair competition makes students consider plagiarism as a substantial option [12]. A survey in Indonesia found that most of the students have lent their work to be copied. It was also found that the students have plagiarised by paraphrasing previously done work without acknowledgement [13].

A survey done on the students doing their higher education in the UK also showed that students perceive plagiarism to be mostly limited to the copying of words and do not understand much about copying of ideas [14]. Research conducted on international students in Canadian Institutions revealed that the reduced knowledge of plagiarism impacted the students to feel anxious and confused [15].

III. Research Question

The goal of this research is to answer the following questions.

1. Are students aware of plagiarism?
2. Why do students plagiarise?
3. What are the differences between the first year students and final year students?
4. How did the students' perception of teachers' behaviour impact the students on plagiarism?

IV. Methodology

A qualitative approach was used to analyse the data. The qualitative data were categorized, and conclusions were derived from them. All the categories are correlated and provide a broader picture together. Semi-structured interviews were used during this approach where students were asked questions. The interviews were held on zoom in English.

A. Participants

Ten engineering students were selected from the College of Science and Technology (CST) from the Information Technology IT department. The College of Science and Technology is an engineering college in the Royal University of Bhutan (RUB) in Phuentsholing, Bhutan, that offers mainly undergraduate education, but also some graduate programmes.

Five students from the first year and five from the final year were selected for the interviews. The students were selected to show different levels of results, but were, except for this, randomly selected within each year. First year students were new to the college, and maybe also new to the concept of plagiarism. On the other hand, final year students should have enough information about plagiarism and the penalties for doing plagiarism.

V. Findings

A. Students' reasons for plagiarism

The categories consist of various interpretations of how students perceive plagiarism, the forms of plagiarism they report practicing, factors that lead students to plagiarise, and factors that prevent them from such practices.

Category 1: Complacent about plagiarism

In this category, we find the thought that students could plagiarise regardless of the situation. Act of plagiarism is perceived as breaching a rule and nothing else. Plagiarism is often triggered by laziness and lack of interest in learning, resulting in copying others' work directly for the completion of assignments and to achieve grades.

One of the students said the following about plagiarism:

> *"Um, plagiarism is basically a kind of rule that…."*

Strict teachers often monitor plagiarism using software tools to check plagiarism. If they happen to find any sort of plagiarism, they will simply deduct the marks or take the issue further and students might have to face more consequences and penalties. This discourages the students from plagiarizing.

Students were asked that if given an opportunity to plagiarise, would they still plagiarise? The responses in this category were that they would plagiarise if they are allowed to do so.

> *"I would plagiarise given an opportunity because while we copy, we do not have to put any effort and it is an easy way of completing works."*

Students could prefer plagiarism regardless of the situation. They find it easier to plagiarise rather than putting the effort into completing the assignment. Plagiarism is viewed as a hurdle that prevents them from copying and getting grades and given an opportunity, plagiarism is taken as a means to complete assignments.

Category 2: Unassertive about plagiarism

In category 2 students do not specifically think of plagiarism as something to be avoided or something to be implemented strictly. Students are most likely to be opportunistic. Circumstances such as having to do

multiple assignments of almost all the courses (around five to six) in a short time frame, and students not having enough time to complete their assignments tend to drive students to plagiarise.

> *"Hmm. I don't think so. I would. If I have time, I probably wouldn't. But if I don't have time, I probably would do that because it would be easier"*

There seems to be an increase in plagiarism when a teacher is lenient. Students were encouraged to plagiarise if a teacher was lenient and would not check for plagiarism on the works submitted by them. Moreover, even if teachers happen to check and find that the work is being plagiarised, students tend to get away taking the advantage of their leniency.

> *"If the tutor is lenient, I think that would prompt me to plagiarise."*

Once the students are warned about plagiarism, they tend to become more cautious about such acts and try to reduce plagiarism. They avoid plagiarism due to the awareness they received from the modules and their tutors.

If the given assignment was easy and of students' interest, they would complete it without plagiarizing. But if it was challenging and not of students' interest, plagiarism would be opted to complete assignments. Given enough time to complete the assignment, students would explore it and avoid plagiarism.

> *"If the assignment is interesting, I would do research on that topic and try not to plagiarise. But if the topic is not of my interest, I would do that depending upon the situation, like if it is tough and if it is okay to be copied, I would do so."*

In this category, perception of plagiarism is mostly neutral, plagiarism is not completely opposed or supported. Plagiarism is mostly promoted by time and situation. Students get affected if the topic of the assignment does not belong to their interest in the study. In that case, plagiarism is opted for comfort and ease.

Category 3: Discourage plagiarizing

In this category, we find the thought that plagiarism is considered morally wrong and students try not to do it as it is something that should be avoided. Such practices are not considered to be helpful in learning and gaining knowledge. Students seem to realize that if they do it on their own, they would be able to learn more, and this drive for learning and growth motivates students to discontinue plagiarism.

Students often tend to copy assignments from friends and tweak some words or variables of codes, they would not directly submit others' work but rather refer to the assignments and try to frame it in their words to avoid plagiarism.

> *"I have never completely copy pasted others' entire work but I have referred to their assignments and tried to frame it in my own words to avoid plagiarism…"*

When students feel like they do not have enough time, information or knowledge about a particular topic and they are not able to move further with the assignment which results in them opting to plagiarise. When students do not have enough confidence in their knowledge, they tend to copy others' work to save themselves from embarrassment and bad grades.

> *"I have plagiarised when there is not enough time and when I do not understand the concept properly. I have plagiarised when I cannot write it on my own."*

This category of plagiarism is seen to be disfavoured and the thought that plagiarism should be avoided and is morally wrong can be found. Plagiarism is considered to prevent learning and impact students negatively. Given an opportunity, students would not plagiarise to complete their work as it is against academic law.

B. Student-teacher relationship

As part of our interviews, we asked each student whether they had ever committed plagiarism in their academic life, and all the students admitted to having plagiarised in different forms. It is observed that the students plagiarise depending on the behaviour of the teachers. The role of the teacher has a substantial impact on students practising plagiarism.

> *"When the tutors are strict about plagiarism, I do not plagiarise…"*

The responses from the students depict that if the teacher is lenient and does not check their plagiarism, the student is more likely to practice plagiarism. Whereas if the teacher is strict and checks the assignments properly, the students tend to put more effort and avoid plagiarizing. Advocating students on plagiarism frequently helped the students to overcome the practice of plagiarism. The courses taught to students about plagiarism helped them to reduce the practice of plagiarising.

Students avoid plagiarising and become more careful about it when their work is being monitored strictly by their teachers. Students faced the consequences if the work they submitted was found to be plagiarised. The consequence includes a reduction in marks, getting a zero to that assignment, and completely disregarding the assignment or redo.

VI. DISCUSSION

A. Students' definition of plagiarism

Students think plagiarism is simply copying others' work, such as assignments, codes, and algorithms without the consent of the original author. Plagiarism is seen as a false display of ownership of the work done by other people. For example, programming codes that are directly copied from their friends or from the internet or the articles written by others. If you portray that someone else's work is yours and does not provide any references or credit to the original

author, then it is considered plagiarism by the interviewees.

Some of the students copy exact articles or codes from the internet and submit them claiming as their own work without providing any references. Some assignment topics are repeated every year. Hence, students tend to ask for assignments done by the previous years' students and copy them.

B. Comparison between first year and final year students.

First year students were mostly more protective of doing plagiarism than the final year ones. They were also more defensive as they were giving reasons on why they plagiarised.

Plagiarism is frequently justified by first year students as a result of their inexperience with college and lack of confidence in their abilities. Final year students, on the other hand, may possess the necessary information, but due to laziness and a lack of time, they may plagiarise.

"I was not confident about my own work….."

First year students were extremely cautious and fearful of deduction in their marks, thus they may have avoided plagiarism. Students in their final year avoided plagiarism because they were more conscious of it.

> *"After reaching my final year, I am more aware now about the intellectual properties and about the plagiarism and what are the consequences of it"*

VII. Conclusions

According to the findings, students' perceptions can broadly be divided into three categories. The first category consists of complacency about plagiarism and preferring to plagiarise regardless of the situation. Plagiarism is found to be an easier alternative rather than putting the effort into completing the assignment. Plagiarism is not viewed as a moral obligation but rather a rule that prevents them from copying and getting grades.

The second category consists of being unassertive about plagiarism and mostly remaining neutral regarding the perception of plagiarism as plagiarism is not completely opposed or supported. It is regarded as opportunistic and often influenced by time, situation and nature of assignments.

The third category consists of perception discouraging plagiarism. Plagiarism is disfavoured and agreed upon by the thought that plagiarism should be avoided and is morally wrong. Plagiarism is perceived as a hurdle between students and their learning.

A relationship between students and teachers is visible during the study. If a teacher is lenient then students are seen plagiarizing more and if there is a strict teacher, it is related to a decrease in plagiarism. Teachers play the role of advocates. With teachers' advocacy and the ways they react to plagiarism, students' behaviour and perceptions are changed. Hence teacher-student relationship plays a vital role. The importance of the teachers' attitudes, both when it comes to plagiarism and to seeing learning, instead of getting a grade, as the core aim of the studies is probably the most relevant insight from this project.

Acknowledgment

We would like to extend our heartfelt gratitude to all the participants, the students at the College of Science and Technology. Special thanks to Uppsala Computing Education Research Group, UpCERG, Uppsala University, Sweden, for helping us to pursue this research and for all the feedback that helped us improve and shape the paper to its final version.

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The Study of English Critical Reading Abilities with Video Sharing on Social Media Platform and Mind Mapping of English Teaching Program Students

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Abstract

English critical reading is an essential ability for higher education in the digital age because university students, especially English Teaching Program students, have to search for large amounts of academic information or research papers on the internet**.** They need to analyze the information they gain from reading, and they have to analyze the data to organize the events or to compare the data and search for reasons to support the data they get**.** In addition, the understanding of idioms, grammar, and sentence structure is important for them to learn**.** Therefore, learning management supporting students to learn anywhere and anytime is the use of video, which is currently available on social media platforms, both on websites and on applications**.**Videos consisted of some content in terms of multimedia, including visual and audio, that helps students learn better**.** Furthermore, mind mapping could help readers present the information they get from their reading through critical reading**.** Mind mapping is a suitable tool for university students to analyze and summarize each topic that is related to each other**.** Moreover, it could encourage students to analyze reading**.** The aims of this research were

1) to examine English critical reading ability and 2) to compare the learning achievement of English Teaching Program students before and after using video sharing on social media platforms and mind mapping. The sample of this research was 25 English Teaching Program students in the Faculty of Education, Phranakhon Si Ayutthaya Rajabhat University. The statistics used in the research were Means and Standard Deviation (S.D.). The results of this research found that the abilities in English critical reading were at a good level and their learning achievement was significantly higher than before.

Keywords— English Critical Reading, Video Sharing on Social Media Platform, Mind Mapping

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***Abstract*— English critical reading is an essential ability for higher education in the digital age because university students, especially English Teaching Program students, have to search for large amounts of academic information or research papers on the internet. They need to analyze the information they gain from reading, and they have to analyze the data to organize the events or to compare the data and search for reasons to support the data they get. In addition, the understanding of idioms, grammar, and sentence structure is important for them to learn. Therefore, learning management supporting students to learn anywhere and anytime is the use of video, which is currently available on social media platforms, both on websites and on applications. Videos consisted of some content in terms of multimedia, including visual and audio, that helps students learn better. Furthermore, mind mapping could help readers present the information they get from their reading through critical reading. Mind mapping is a suitable tool for university students to analyze and summarize each topic that is related to each other. Moreover, it could encourage students to analyze reading. The aims of this research were 1) to examine English critical reading ability and 2) to compare the learning achievement of English Teaching Program students before and after using video sharing on social media platforms and mind mapping. The sample of this research was 25 English Teaching Program students in the Faculty of Education, Phranakhon Si Ayutthaya Rajabhat University. The statistics used in the research were Means and Standard Deviation (S.D.). The results of this research found that the abilities in English critical reading were at a good level and their learning achievement was significantly higher than before.**

Keywords— English Critical Reading, Video Sharing on Social Media Platform, Mind Mapping

I. INTRODUCTION

English reading is one of the most important abilities for students in the 21st century. For example, reading chat messages, reading comments through social media, and reading from applications such as Facebook, Line, YouTube, WhatsApp, and E-book [1] [2]. It is also necessary to improve reading in order to search for some information through websites or web applications. The students use academic information and search for new information to apply to their teaching, doing their reports, doing their homework, or applying for their education [3] [4]. English is an international language and it is widely used around the world. However, there is a variety of information available on the Internet that might not be reliable. The students should analyze the data they get from their reading, make their own conclusions and create their own knowledge by searching for some information from the Internet, and finally, they could integrate their knowledge into their further education. It is the process of English critical reading ability at a higher level of proficiency and it is more complicated than normal English reading ability. Students need to read, and they are able to analyze the organization of the information and the sequence of the events. They are able to compare the information through their reading and to identify cause and effect while reading. Finally, the students should find and solve the problems when they read [5]. All of the process is the ability to read skills that the English Teaching Program students should develop in order to raise their level of English reading ability to apply to their studies and to develop their reading skills so that they can teach their students in the future [6].

The ability of university students to apply the process of critical thinking to analyze the information they read and to blend the abilities in English reading could be identified. The students have to read and analyze the important points of what they read, and then they need to organize their contents and order crucial information. The students need to find supporting details to support the information they have already analyzed. Moreover, the linking of the information could be used as a guideline to solve the problem of reading [7]. The experience of the researcher in teaching English reading has found that the university students could not analyze the information, so they could not achieve their critical reading. Hence, it is important to develop their English critical reading skills at a higher level by using the videos. Using videos is a supplementary teaching medium for students, and they are able to study anywhere and anytime. It is a medium that can present a variety of information, including text, content, pictures, and sounds [8]. It is also famous and widely used during COVID-19 because it can be applied for both synchronous and asynchronous

time. At present, videos are often found on video sharing social media platforms that are easy to access, such as YouTube, TikTok, or websites [9] [10]. The research of Tan, Pua, Wong, and Yap (2021) [11] identified that using video-sharing on social media platforms is a great way to help learners understand. It benefits teaching and learning in addition to being simple to use and providing a wide range of content [12].

There are various methods to present the process of the analysis of students in English, and it could help students present the information in a systematic way and make it easy to understand after learning with video sharing on social media platforms. Mind mapping is another idea that can help students improve their ability in English critical reading. It is a process that the students use to analyze the information from their English reading. They classify the information into different topics and identify the related or supporting details. So, the students could understand the relationship between each topic and the details that the students had already analyzed while reading. Using mind mapping could support creative thinking in recording the data by creating beautiful mind maps in a creative way. It could make the students understand easily, encourage the students to have free ideas in creating mind maps or support the brainstorming of students in their groups. In addition, mind mapping could help the students categorize and analyze the data. It also supports short-term and long-term memory in an effective way, and it can stimulate the students to be good learners. It is a modern tool and it is useful to develop university students [13].

From the information mentioned above, it could be concluded that English critical reading is necessary for the students in the English Teaching Program to develop their abilities in teaching and learning and self-development. However, the students have some problems with English reading and their ability in critical reading is not good enough. The use of video sharing on social media platforms is a very popular teaching and learning tool during the COVID-19 epidemic. Using a mind map could help students support the process of analyzing reading data and create a mind map that could show connected data. Consequently, the researcher is interested in studying English critical reading ability with video sharing on social media platforms and creating mind maps of English Teaching Program students to develop their reading abilities and could be used as a guideline in teaching and learning management in the future.

RESEARCH OBJECTIVES

1. To study the ability in English critical reading with video sharing on social media platforms and mind mapping of English Teaching Program students.

2. To compare the learning achievement of English Teaching Program students before and after using video sharing on social media platforms and mind mapping

II. METHODOLOGY

1. The population used in the research was 102 English Teaching Program students. The sample size for this research was 25 English Teaching Program students. The sample was a purposive sample. All of the sample were enrolled in English critical reading for English Teaching Program students.

2. The research instruments were lesson plans, videos, tests, and English critical reading abilities assessment forms. The social media platforms used in this study were the YouTube platform and the research instrument was assessed through an expert assessment of the Index of Item-objective Congruence (IOC). The mean IOC score was 0.67–1. The instrument was tried out with non-sampled English Teaching Program students who were not in the sampling group. The reliability of the learning achievement test was 0.75.

3. Data collection and data analysis

3.1 This research is experimental research. The researcher conducted the experiment and collected the data in the 2nd semester of 2021. The researcher assigned the students to self-learning by watching the video sharing on social media platform before class to collect data. They learnt five patterns of organization by watching the video and doing some activities in the class. After the students learnt and did the activities, they took a test by wringing mind mapping of five patterns of organization.

3.2 The researcher used criteria as follow:

Topic	Score		
	3	2	1
1. Task	structure is all correct.	structure is partially correct	incorrect structure
2. Answer	All answers are correct.	A partly correct answer	All answers are incorrect.
3. Language	correct language	language is partially correct	Incorrect language
4. Sentences	concise language	Language is partially understood.	don't understand
5. Grammar	All grammar is correct.	Grammar is partially correct.	Incorrect grammar

After giving the score, the researcher used the English critical reading abilities assessment form by using the Rubric score. The criteria are as follows:

12-15 means that the students have English critical reading abilities at good level.

8-11 means that the students have English critical reading abilities at medium level.

5-7 means that the students have English critical reading abilities at low level.

3.3 The statistics used to analyze data were mean, standard deviation and t-test to compare the ability of learning achievement before and after using video and mind mapping

III. RESULTS

TABLE 1: The study of English critical reading abilities through video sharing on social media platforms and mind maps of English Teaching Program students.

Factors	Score	Range
Listing	13.32	Good
Sequence	13.88	Good
Comparison and Contrast	12.04	Good
Cause and Effect	12.20	Good
Problems and solution	12.36	Good
Average	12.76	Good

The results in Table 1 have shown that the ability in English critical reading by using video sharing on social media platforms and mind mapping of English Teaching Program students was at a good level. The average score was 12.76, and the highest levels were sequence and listing, respectively. The finding of the result could be implied that mind mapping could show the understanding of the reader and they could express their understanding through mind mapping.

TABLE 2: The comparison of leaning achievement of English Teaching Program students before and after using video sharing on social media platforms and mind mapping.

Experimental Group	n	Full score	$\overline{X}$	S.D.	t	Sig
Pre-Test	25	30	18.4	2.44	20.72	0.00
Post-Test	25	30	24.60	2.40		

Table 2 shows that the learning achievement of English Teaching Program students was higher after using video sharing on social media platforms and mind mapping than before using them, with a statistically significant difference at the.05 level.

V. DISSCUSSION AND CONCLUSION

The results of the study of English critical reading abilities through video sharing on social media platforms and mind mapping from English Teaching Program students have been published. They found that the ability in English critical reading of the students was at a good level. It could be implied that video sharing on social media platforms could help the students learn step-by-step. They could follow the concept of the contents of the English critical reading process. The students could access the content in the video at any time via electronic devices such as their smart phones, tablets, or computers. The students studying through videos could organize their ideas in an ordered sequence of the events or analyze the structures of the passage. They could list the content, compare the information, identify cause and effect, and analyze problems and solutions. Finally, they could create their mind maps after reading and analyzing the passages. From mind mapping created by English Teaching Program students, they could present their understanding and their knowledge from analyzing the information from the passage or reading material to clearly identify key points [14] [15] [16]. The results of the study were related to the concept of English critical reading, which identifies the ability to use the process of critical thinking in what they read, to understand the passage they read, and evaluate and decide the importance of the information they read. The students could analyze the complicated information and they could apply their knowledge. In a digital world where information is abundantly available on the Internet, it is essential for students to develop their reading skills. The students should focus on English critical reading because it could help them to be media literate and have critical thinking when getting a lot of information. This related to the research of Ali, Balta and Papadopoulos (2022) [17], who conducted his research on social media platforms and social enterprise: bibliometric analysis and systematic review. It has been shown that using videos on social media can help students achieve their success and support teaching and learning effectively. Furthermore, the use of mind mapping also helps learners enhance their critical ability to be more effective. The research on the effect of mind mapping on young children's critical thinking skills from Polat and Aydin (2020) [18] identified that mind mapping could help students develop higher analytical abilities and enhance individual learners' skills in interpreting, analyzing, reasoning, and evaluation.

The comparison of learning achievement of English Teaching Program students before and after using video sharing on social media platforms and mind mapping has found that the learning achievement of ability in English critical reading after using video sharing on social media platforms and mind mapping was higher than before using them. The results of this study tend to be the same as those of other studies related to critical reading. It could be possible that the process of teaching and learning through videos could encourage the students' interests. The students learned through their perceptions, including watching, listening, and reading information through video. Then they made a conclusion, analyzed what they knew, and then showed their understanding through mind mapping. In conclusion, the students could learn concepts and the process of critical reading by doing mind mapping, and finally, their learning achievement in English critical reading was higher. The results of the study were the same as the research from Langprayoon and Chobthamdee (2020) [19]. They studied the effect of blended learning with collaborative learning via social networking on video sharing to enhance the English speaking ability of students in the Faculty of

Education, and the results showed that video sharing could affect learning achievement in a better way. Besides, the results from the research of Fu and et al. (2019) [20] who conducted the research on the impacts of a mind mapping-based contextual gaming approach on EFL students' writing performance, learning perceptions, and generative uses in an English course applied and used mind mapping for teaching and learning with EFL students. It was found that the learning achievement of EFL students was increased in a statistically significant. From the related studies mentioned above, it could be said that English critical reading could be developed by teaching through video sharing on social media and mind mapping could help students improve their reading skills in English statistically significantly.

VI. RECOMMENDATIONS

1. The results of the study could be used as a guideline for teachers who are interested in using video on social media platforms and in mind mapping. Thus, the instructors should clearly learn how to create videos and use social media platforms, as well as how to create mind maps before teaching.

2. Videos on social media platforms and the use of mind mapping should be designed to develop other abilities such as listening, speaking and writing.

3. This research can be used as a guideline to improve the English critical reading abilities of students in English majors. Therefore, the research should be conducted for students in different majors.

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Halocode-based Gamepad Development

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Abstract

In this paper, a Halocode-based Bluetooth gamepad is developed for use as a physical computing device for students. Hardware for the gamepad includes a power and signal managing circuit and a 3D printed case. Software made to communicate with the gamepad comprises of a device package for the mBlock programming software and a responsive gamepad driver. Experiments reveal the mean data rate to be 7.65Hz.

Keywords– Scratch, physical computing, teaching kit, Makeblock, gamepad

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***Abstract*— In this paper, a Halocode-based Bluetooth gamepad is developed for use as a physical computing device for students. Hardware for the gamepad includes a power and signal managing circuit and a 3D printed case. Software made to communicate with the gamepad comprises of a device package for the mBlock programming software and a responsive gamepad driver. Experiments reveal the mean data rate to be 7.65Hz.**

Keywords*— *Scratch, physical computing, teaching kit, Makeblock, gamepad

I. INTRODUCTION

Reinforcing and retaining newly learned skills through relatable and clear practical activities are crucial for students to store long-term knowledge [1]. STEM subjects, a major part of the labor market [2, 3], are advancing towards curriculums based on integrated STEM [4], an approach where students must apply knowledge and methods from various STEM disciplines in order to solve complex transdisciplinary problems [5].

Physical computing, where programmable devices are used to implement systems that can interact and sense their environment, is known for promoting students' imagination, uptake, cognitive labor, and confidence [6]. The use of tangible devices allow students to learn in a more natural way [7] and project-based courses promote students' to come up with an imaginative solution, as most projects may have many solutions.

While learning to program can develop young learners' computational thinking [8], students with apparent programming aptitude may have misconceptions of the computer science field or be deterred by the perceived difficulty of STEM topics [9]. Block-based programming, typically with Scratch, is a popular introductory approach to programming [10], although it can lead to the learner having misconceptions about certain programming concepts [11]. Our school utilizes mBlock, a Scratch offshoot developed by Makeblock [12] for use with their educational kits and toys, such as the Codey Rocky, mBot, and Halocode. Halocode, shown in Fig. 1, is an ESP32-based development board with four touch-sensitive inputs, microphone, accelerometer, and gyroscope, and is an example of a physical computing device.

Halocode kits employed by our school, shown in Fig. 2(a), are made from components of the Halocode Standard Kit and are based on one of Makeblock's sample project guides. We found that our students had difficulties keeping hold of the Halocode while testing their Halocode-controlled programming projects.

(a) Top (b) Bottom

Fig. 1. Halocode Board.

(a) Kit with alligator clips and conductive tape

(b) Gamepad Kit

Fig. 2. Halocode Kits.

In this paper we focus on the development of a Halocode-based handheld gamepad capable of connecting to low-cost Bluetooth adapters. In order in improve the aesthetics, handling, and accessibility of the Halocode kits and to enhance students' experience with physical computing devices, we developed the gamepad shown in Fig. 2(b) and its supporting software.

This paper is sectioned as follows. Section 2 details the steps taken during design and development. The next section describes the performance investigation and discusses the results. The last section summarizes the project development and mentions potential beneficial updates.

II. GAMEPAD SYSTEM SETUP

A. PCB

The circuit from Fig. 3 was printed on the PCB displayed in Fig. 4. It is designed to mount the Halocode, attach a configurable Bluetooth adapter, act as a multi-input touchpad, and to manage the LiPo battery. Intending to avoid mechanical wear from long-term use of pushbuttons, we placed large conductive pads, shown in Fig. 4(a), that rely on the touch sensors of the screw-mounted Halocode to act as directional inputs.

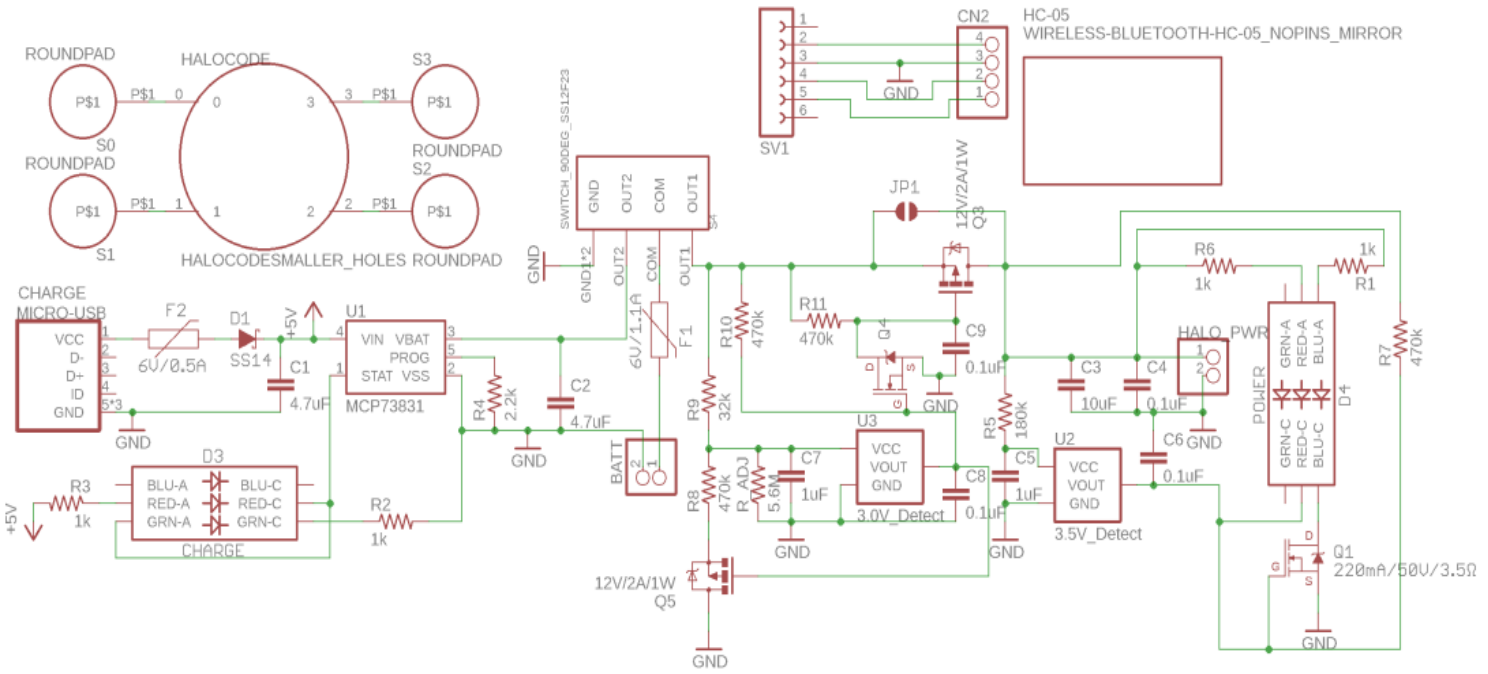
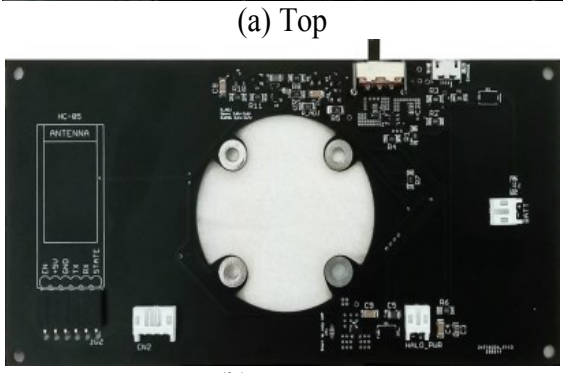


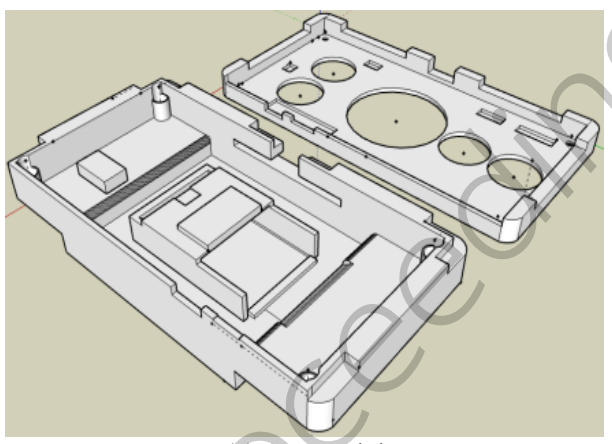
Fig. 3. Gamepad circuit schematic.

(a) Top

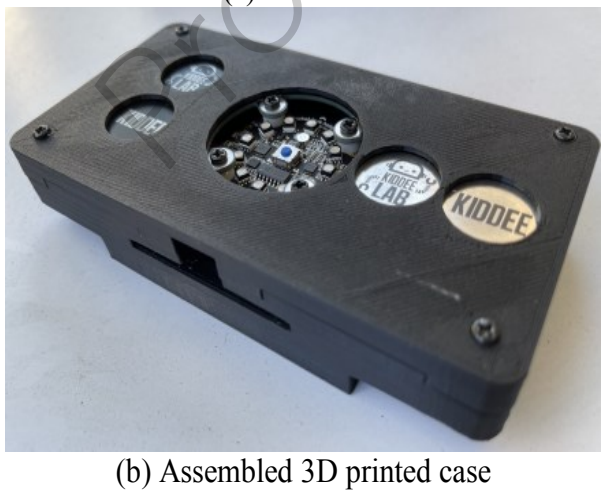


(b) Bottom

Fig. 4. Manufactured Gamepad PCB.



(a) 3D model



(b) Assembled 3D printed case

Fig. 5. Joystick case.

Two power modes, selectable by the sliding SPDT switch shown in Fig. 4(b), are available: "Charging" and "On". In "Charging" mode, a 5V supply to the PCB Micro USB socket will charge the battery. The gamepad may be safely activated while charging by powering the Halocode directly with another power-supplying Micro USB cable. Switching to "On" mode turns on the gamepad by linking the battery to the Halocode external power supply port. Table 1 elaborates on the meaning of each color of the status indicator lights located in the top-left of Fig. 4(a).

B. Case

As presented in Fig. 5, we enclosed the gamepad components in a 152×78mm PLA case. The case provides a battery holder, touchpad openings, and a gap to allow access to the Halocode Micro USB socket. The translucency of PLA ensures that the indicator lights may be seen through the case.

C. Bluetooth

To allow custom protocols and to permit the use of most built-in Bluetooth adapters and generic low-cost Bluetooth dongles that only support Bluetooth V2.0, we utilize the Serial Port Profile-enabled HC-05 Bluetooth module as our configurable Bluetooth adapter. This acts as a workaround to utilizing the proprietary Bluetooth dongles that are typically required to communicate wirelessly between the Halocode and a host computer.

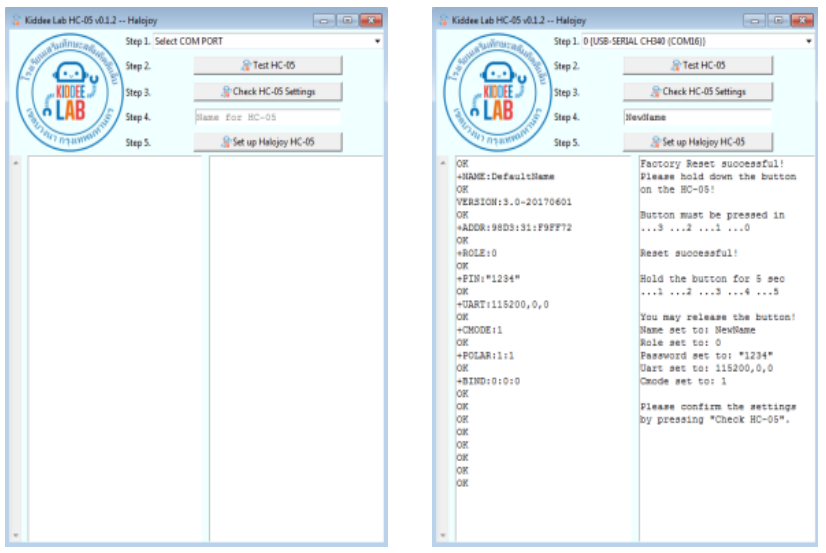
To simplify the HC-05 configuration process of and enable lay users to setup the HC-05 without in-depth knowledge of the command protocol, we developed the python-based GUI shown in Fig. 6.

D. Extension

A JavaScript-based Extension Builder [13] provided by mBlock allowed the development of a Serial Port device package for the gamepad. Two code execution modes exist in mBlock: Live and Upload. Upload mode compiles the program and uploads it to the connected device. In Live mode, mBlock actively communicates with the connected device without uploading the program to the device.

TABLE I. STATUS INDICATORS

Indicator Type	Status	Color
Charging	Charging	Red
	Fully Charged	Green
	Error	Yellow
Battery Level	Normal	Blue
	Low	Red



(a) Initially opened (b) Completed HC-05 setup

Fig. 6. HC-05 Configuration GUI.

Only Live mode was set up for our device package, as the gamepad is a slave device and therefore the device package must allow the user to send commands actively during execution. Figure 7 shows the template provided to act as the starting point for user-made programs and provides data rate information to enable users to determine if communication has been interrupted. Moreover, Fig. 7 displays the device-specific blocks available for the gamepad, such as the "all LEDs light up" block that sets all LEDs on the gamepad to a user-specified color. The gamepad package sequence for reading data is presented in Fig 8.

E. Communication

Communication from mBlock to the gamepad, to request data or to control the Halocode LEDs, is based on a modified Firmata protocol [14], where each packet is wrapped by a specific start byte and end byte that are never found within the data bytes.

Although it would be preferable to have the same protocol when communicating in either direction, the protocol to send data from the gamepad to mBlock uses a null-terminated string.

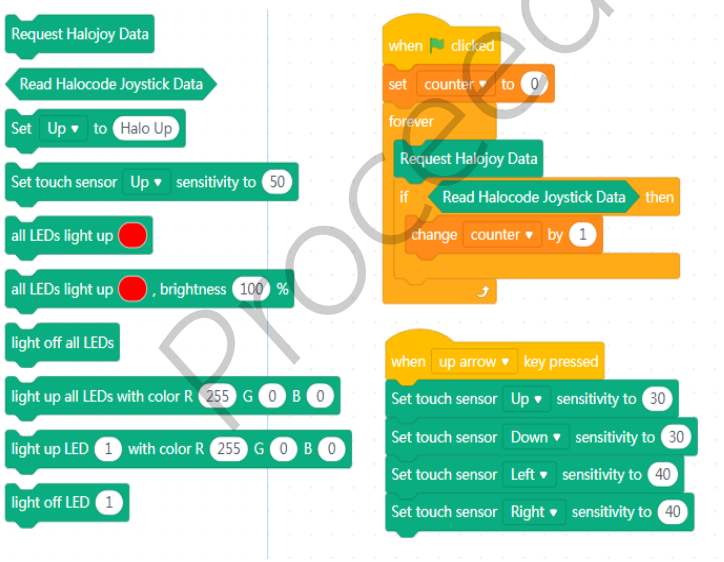


Fig. 7. Template blocks and available blocks for the device.

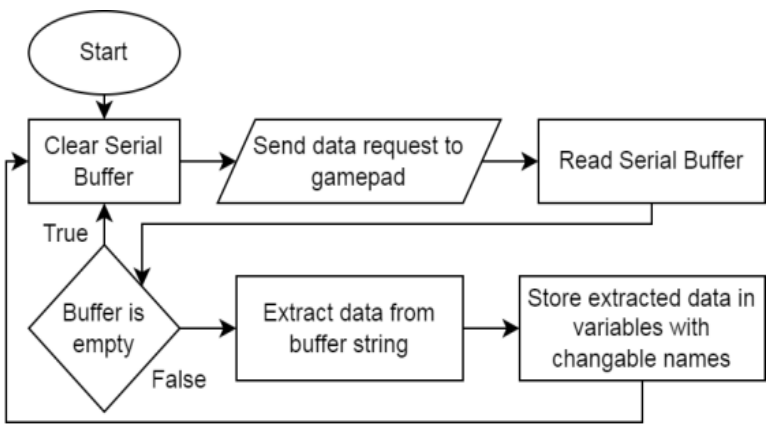


Fig. 8. Data reading flow chart for the gamepad device package.

TABLE II. NULL-TERMINATED STRING PACKET

Bytes			
0-14	**15**	**16-19**	**20-22**
Header	Pushbutton	Touchpads	Microphone
23-25	**26-29**	**30-33**	**34**
Shake	Pitch	Roll	Alive Counter

TABLE III. DATA RATE MEASUREMENT RESULTS

Test Type	Time range (s)	Filtered Data Rates (Hz)		
		Mean	**Min**	**Max**
Python	0-5000	416.98	383.32	461.07
mBlock	0-4794	7.65	4.27	8.28
	4794-5000	4.41	4.11	4.61

We observed that the data sent to mBlock via the serial port reader function provided by the extension builder randomly dropped 1 to 8 of the leading bytes. Due to this issue, and to allow lay users to understand the raw data, we selected a null-terminated string with a long header of throwaway bytes as our data packet. An alive counter is added to the packet to detect communication failure by determining whether the alive counter value in the previous packet is different from the current one. It can also be used to measure the communication speed by finding the elapsed time for each counter update. The data packet information is presented in Table 2.

III. EXPERIMENTS AND RESULTS

Our experiments focus on the data transmission speed from the gamepad to a Bluetooth-enabled computer, as experiencing lag is expected to be detrimental to students' motivation. Two data rate tests ran for 5000s: Reading via Python and Reading via mBlock. We included a Python-based data rate measurement as a baseline to compare with the mBlock test. As a control, we found that the data rate of the Halocode in Live mode when connected to the Makeblock Bluetooth dongle is 32Hz. The mean, maximum, and minimum data rates of each experiment are presented in Table 3.

A. Reading via Python

Our Python-based data rate measurement program monitors the data rate by finding and logging the elapsed time between each successfully received packet and recording any timeouts or improper packets. Figure 9 displays the results of the trial.

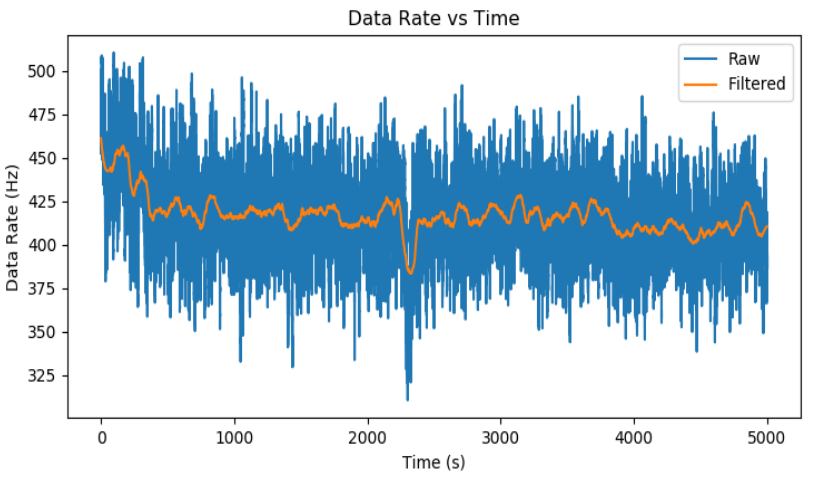


Fig. 9. Python-based data rate measurement results.

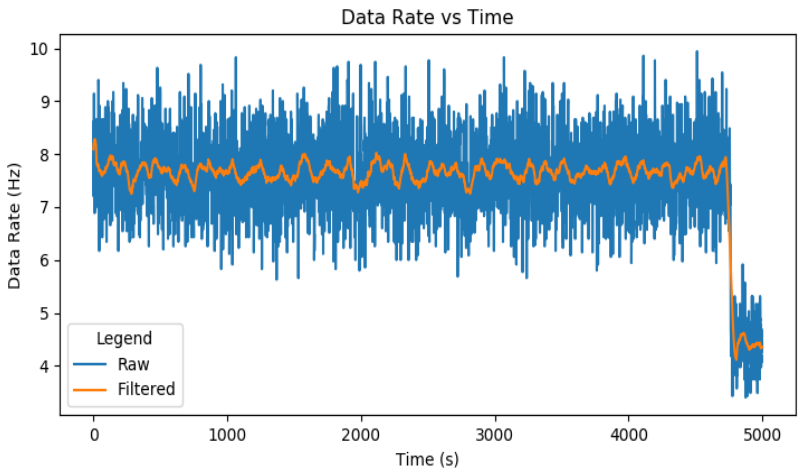


Fig. 10. mBlock-based data rate measurement results

As shown in Fig. 9, an average data rate of 416.98Hz was maintained for a majority of the run time.

B. Reading via mBlock

To create a simple block-based data rate measurement program, we made use of the alive counter of the gamepad data packet: While requesting data from the gamepad in one loop, we also continuously check if the value of the alive counter has changed. We increment a data counter for any change in the value of the alive counter and store it in one-second increments while simultaneously resetting the data counter. Results for this trial are presented in Fig. 10.

We can see in Fig. 10 that the typical data rate prior to 4794s is almost 8Hz. After 4794s, the data rate drops to nearly 4Hz. On a repeat of the trial we found that this quirk reoccurs after a similar amount of elapsed time. Power cycling the gamepad restores the speed, but requires reestablishing the Bluetooth connection. Comparing the official Bluetooth module data rate to the one found in this test, we see that the official components are much faster than the gamepad when used with mBlock.

IV. Conclusion and Future Work

In this paper, we developed a portable Bluetooth-based serial gamepad that utilizes a Halocode board as its controller for enhancing students' positive effects of physical computing. We designed and produced a PCB to manage the power and inputs of a screw-mounted Halocode. A compact 3D printed case was used as the gamepad housing. Employing a HC-05 Bluetooth module permitted low-cost Bluetooth adapters to connect to the gamepad, widening the range of compatible devices and software of the Halocode. Utilizing the mBlock Extension Builder we created a device package for the gamepad with blocks similar to those found in the Halocode device package. Communication from the gamepad to the computer was wrapped in a null-terminated string while communication in the other direction utilized a modified Firmata protocol. Data rate measurement tests run via Python and mBlock resulted in the average speeds of 417Hz and 7.65Hz, respectively.

While documentation exists for the mBlock Extension Builder, much of the device package development was spent discerning the optimal way to receive serial data and to discovering methods to use functions that utilized undocumented classes.

Prospective improvements and future research are as follows: allow the device operate while charging without any additional cables, ensure safe removal of expanded LiPo batteries, and examine students' responses and satisfaction to this device in comparison to the initial kit.

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P02323

The Analysis of Translation Strategies on Thai Country Songs with Critical Thinking in the 21st Century

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Abstract

The purpose of this research aimed 1) to study the translation strategies of Thai country songs (Lukthung) from Thai to English; and 2) to analyze the problems found in the process of translating Thai country songs into English with critical thinking. In this study, there were 15 selected song lyrics which have been released between 2018-2020. Both the quantitative and qualitative methods were used in this study. The analysis was based on Baker for poetry translation strategies and Duron et al. for critical thinking in the 21st century. For the translation strategies, there were totally 8 strategies namely translation by a more general word, by a more neutral or less expressive word, by a cultural substitution, by a borrowing word, by a paraphrase using related words, by a paraphrase using unrelated words, by omission, and by illustration. The poetic form of Thai country songs represented the difference between Thai and English as well as the socio-culture between source language and target

language. For the analysis of problems, there were main 5 categories namely 1) a deficit in Thai language skill, 2) a deficit in English skill, 3) the linguistic problems on sentence structure (syntax), 4) the problem on social and cultural context, and 5) the lexical problem for selecting words. The findings could develop the suitable translation methods and contribute to the teaching of the translation of Thai country songs into English.

Keywords—Translation Strategies, Thai Country Songs, Critical Thinking, 21st Century

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***Abstract*—**The purpose of this research aimed 1) to study the translation strategies of Thai country songs (Lukthung) from Thai to English; and 2) to analyze the problems found in the process of translating Thai country songs into English with critical thinking. In this study, there were 15 selected song lyrics which have been released between 2018-2020. Both the quantitative and qualitative methods were used in this study. The analysis was based on Baker for poetry translation strategies and Duron et al. for critical thinking in the 21st century. For the translation strategies, there were totally 8 strategies namely translation by a more general word, by a more neutral or less expressive word, by a cultural substitution, by a borrowing word, by a paraphrase using related words, by a paraphrase using unrelated words, by omission, and by illustration. The poetic form of Thai country songs represented the difference between Thai and English as well as the socio-culture between source language and target language. For the analysis of problems, there were main 5 categories namely 1) a deficit in Thai language skill, 2) a deficit in English skill, 3) the linguistic problems on sentence structure (syntax), 4) the problem on social and cultural context, and 5) the lexical problem for selecting words. The findings could develop the suitable translation methods and contribute to the teaching of the translation of Thai country songs into English.

Keywords—Translation Strategies, Thai Country Songs, Critical Thinking, 21st Century

I. INTRODUCTION

Translation is an operation of replacement of textual material in the source language by equivalent textual materials in the target language. [1] In linguistics, translation has been provided by critical thinking. Translation could perfoem the lexicon, grammatical structure, communication situation, and cultural context. [2] This process reconstructed the same meaning using the appropriate lexicon and grammatical structure in the target language and its cultural context.

In the present era of globalization, translation plays an important role to convey the message from one language to another. Nevertheless, translation is not an easy task as people can witness many cases of wrong translation. [3] For this reason, the study of translation emerged as a new academic field during the 21st century, focusing on the higher education. [4]

For the translation strategies, Baker [5] identified 8 categories of non-equivalence at word and sentence level : translation by a more general word, by a more neutral or less expressive word, by a cultural substitution, by a borrowing word, by a paraphrase using related words, by a paraphrase using unrelated words, by omission, and by illustration.

Music is truly an international language. A well-known song in another language will probably find that you recognize it although you do not understand the words and sentences of that particular version because of the rhythm and melody. [6] It is a challenging task for translators.

Consequently, translation of song lyrics is completed because it requires the translator to make choices of words and to consider both the rhythm and melody [7]. Nevertheless, song translation could vastly transfer the cultural communication. Thai country songs have reflected both traditional and cultural aspect in Thai society. [8]

In 21st century, critical thinking has been called the art of thinking about thinking. It could help formulate ,solve a problem, make a decision, and fulfill a desire to understand. [9] The critical thinking also reflects the norms, culture, and way of life in society.

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For this study, 15 Thai country songs were analyzed to find out the translation strategy and to investigate the problems on song translation throughout the critical thinking. This research could be applied to teach and to practice translating Thai and English in classroom with the authentic material. Additionally, the results could be a guideline to improve the quality of translated works, especially the song translation.

II. METHODOLOGY

A. Scoping and study site

The present study posed mainly 2 research objectives as follows:

1) to study the translation strategies of Thai country songs (Lukthung) from Thai to English.

2) to investigate the problems found in the process of translating Thai country songs into English with critical thinking.

B. Sampling and data collection

Both the quantiative and qualitative methods were used in this study. All data was collected and analyzed unto frequency and percentage.

The data were obtained from the original Thai country song lyrics from the English translated versions of 15 songs. Only song lyrics from 2018 to 2020 were selected. The English versions of the selected songs were translated by Dr. Samita Muadtong (Dr. P' Nui in English breakfast.) including with:

1.เลิกคุยทั้งอำเภอเพื่อเธอคนเดียว

(I talk only to you)

2.ฝากใบลา

(A sick leave with tears)

3.เฮ็ดทุกวิถีทาง

(I do everything to make you my boyfriend.)

4. ทานหมาอย่าหัวซากัน

(It's like I give food to dogs.)

5.สายแนนหัวใจ (Soulmate)

6.น้องง่ายกับอ้ายผู้เดียว

(I'm easy only for you.)

7.ผู้สาวขาเลาะ (A party girl)

8.ผู้สาวขี้เหล้า (A drunkard)

9.ผู้สาวขาเฟี้ยว (A cool girl)

10. สาวนุ้ยสายเปย์ (All I pay, sugar mama)

11. บ่เป็นหยัง (Never mind)

12. เจ็บละเนาะ (I am so hurt.)

13. กลับคำสาหล่า (Please hold your tongue.)

14. ขีดอันตราย (In a coma)

15. เต่างอย (Tao Ngoi)

For data analysis, the original Thai country lyrics of the songs were taken from https://music.trueid.net/th-th/lyrics/lyrics-country and the Thai translated versions of the song lyrics translated by Dr. Samita Muadtong on English cover, the official YouTube channel.

C. Theoetical framework

A framework which deals with translation strategies at word and sentence in the research is the one proposed by Mona Baker. There are 8 categories namely translation by a more general word, by a more neutral or less expressive word, by a cultural substitution, by a borrowing word, by a paraphrase using related words, by a paraphrase using unrelated words, by omission, and by illustration.

For a framework which deals with critical thinking, it is the one prosed by Vincent Ruggiero. This framework emphasizes the critical thinking skills ;for instance seeing problem as exciting challenges, and understanding as a goal, thinking before acting.

D. Research methodology

To achieve the purposes of the research, the procedure was as follows:

1. The 15 Thai country songs translated into English which were divided line by line to analyze the translation strategies and problems on song translation.

For instance :

Song title : ผู้สาวขาเลาะ) A party girl(

Source text :

การบอกการบ้านบ่เคยมี

Target text: I've never done my homework.

2. For Baker's framework, the 8 translation strategies were employed and were calculated in a percentage in order to compare the frequency of the translation strategies.

3. In studying the problems on song translation, Ruggiero's framework was analyzed by using the critical thinking in textual standards. The problems on song translation were calculated in a frequency and percentage.

4. The conclusions were drawn from the results and recommendations were made for further translation studies.

III. RESULTS

The original song lyrics and the English translated versions of 15 songs were realized to investigate the translation stragegies and to find the frequency and percentage. The result was shown as on the table below.

TABLE I. FREQUENCY AND PERCENTAGE OF EACH TRANSLATION STRATEGY AT WORD AND SENTENCE LEVEL

No.	Translation strategy		
	Types of translation strategy	***Frequency***	***Percentage***
1.	Translation by paraphrase using unrelated words	224	58.95
2.	Translation by using a borrowing word or loan word plus explanation	42	11.05
3.	Translation by paraphrase using a related word	35	9.21
4.	Translation by a more general word (super ordinate)	27	7.11
5.	Translation by a more neutral/less expressive word	23	6.05
6.	Translation by cultural substitution	16	4.21
7.	Translation by illustration	13	3.42
8.	Translation by omission	-	-
Total		380	100

According to table I, there were main 8 translation strategies based on Baker's framework. These strategies were used in the translation of Thai country songs form Thai into English versions. The most frequent translation strategy found was translation by paraphrase using unrelated word (58.95%), followed by translation by using a borrowing word or loan word (11.05%), translation by paraphrase using a related word (9.21%), translation by a more general word (super ordinate) (7.11%), translation by a more neutral/less expressive word (6.05%), translation by cultural substitution (4.21%), and translation by illustration (3.42%), respectively. Nonetheless, translation by ommission was not found in this study because of the linguistic difference (syntax) between Thai and English. In Thai language, the omission could appear in part of speech like subject pronoun, object pronoun, noun, and adverb. In contrast, English sentence avoided omitting like a dummy subject (it and there.)

Based on the results, translation by paraphrase using unrelated word was the most frequent translation straegy in this research. Due to the purpose of song, it aimed to entertain the audiences. The song lyrics needed to please the ears of the listener and to be poetic, for this reason, the translation strategy could not avoid creating the appropriate words and sentences.

TABLE II. THE PROBLEMS ON SONG TRANSLATION

No.	The problems on song translation		
	Types of problem	***Frequency***	***Percentage***
1.	A deficit in Thai language skill	13	30.23
2.	A deficit in English skill	11	25.59
3.	The lexical problem for selecting words	9	20.93
4.	The problem on social and cultural context	6	13.95

No.	The problems on song translation		
	Types of problem	*Frequency*	*Percentage*
5.	The linguistic problems on sentence structure (syntax)	4	9.30
Total		43	100

In table II, there were 5 problems on song translaiton based on Ruggiero's framework considering with 15 Thai country songs. The most frequent problem on song transltion was a deficit in Thai language skill (30.23%), followed by a deficit in English skill (25.59%),the lexical problem for selecting words (20.93%),The problem on social and cultural context (13.95%), and The linguistic problems on sentence structure (syntax) (9.30%) respectively.

For the study, a deficit in Thai language skill was the most problem on song translation, especially the reading skill. Moreover, the interpretation also played an important role in this skill. In terms of the problem on social and cultural context, the dialect was used in Thai country song, in particular Northeastern dialect or Isaan dialect. As for the content analysis, Thai country songs could reflect Thai culture and way of life.

As the linguistic problems on sentence structure, passive voice was used both negative and positive sentence for Thai version such as ถูกหวย (to won the lottery) ถูกต่อว่า (to blame) and so on.

IV. DISCUSSION

According to Baker (1992), there were main 8 translation strategies in this research. This framework has provided the useful non-equivalence both word and sentence level. Moreover, in a study of song translation by Akerstrom (2009), the strategy of paraphrase was the most common translation strategy used. This straegy repeated both the written and spoken text.

However, the traslation by omission was not found in this research. For Thai language, the omission both subject and object could be done because of the syntactic strcuture and space limitation in a song phrase.

For the critical thinking, Ruggiero's framework (2013) was valuable in the translation problems. The framework could show both the linguistic and social problems on song translation.

V. CONCLUSION

In summary, the findings of the research have indicated the various translation strategies. These strategies could cope with non-equivalence both word and sentence level. Furthermore, the critcal thinking skill could show the problems on song translation like the differences of linguistic constructions between Thai and English, as well as the socio-culture both the source and target text.

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P02375

Creating Instructional Media through Video Learning on Social Media Platforms for Graduate Diploma in Teaching Profession Students

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Abstract

Video learning is one of the most important teaching materials for learning management in the digital age because the production process is convenient, it is easy to use a smartphone or tablet to create a story, and it can be edited with a program or application. Finally, this video could be used in teaching. Furthermore, the videos could be published through social media for video sharing. Therefore, graduate diploma in teaching profession students could watch this video to study at any time they wanted. The students need to learn about instructional media creativity. There are a lot of instructional media, such as video publishing on social media, and the students could learn by themselves, and they could be utilized for further teaching. The purposes of this study were 1) to study the ability to create instructional media and 2) to compare learning achievements before and after using video through social media platforms of graduate diploma in teaching profession students. The sample for this study was selected by using simple random sampling. The 29 graduate diploma in teaching profession students were the sampling group in this

study. The research instruments in this study were videos published on social media platforms, a media creation competency evaluation form, and a test. The statistics used in this study were means, standard deviation (S.D.) and t-test. The study's findings revealed that graduate diploma in teaching profession students had a high level of instructional media creativity, and their learning achievement after learning through video was significantly higher than before learning.

Keywords—Creating Instructional Media, Video Learning, Social Media Platforms

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Creating Instructional Media through Video Learning on Social Media Platforms for Graduate Diploma in Teaching Profession Students

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***Abstract*— Video learning is one of the most important teaching materials for learning management in the digital age because the production process is convenient, it is easy to use a smartphone or tablet to create a story, and it can be edited with a program or application. Finally, this video could be used in teaching. Furthermore, the videos could be published through social media for video sharing. Therefore, graduate diploma in teaching profession students could watch this video to study at any time they wanted. The students need to learn about instructional media creativity. There are a lot of instructional media, such as video publishing on social media, and the students could learn by themselves, and they could be utilized for further teaching. The purposes of this study were 1) to study the ability to create instructional media and 2) to compare learning achievements before and after using video through social media platforms of graduate diploma in teaching profession students. The sample for this study was selected by using simple random sampling. The 29 graduate diploma in teaching profession students were the sampling group in this study. The research instruments in this study were videos published on social media platforms, a media creation competency evaluation form, and a test. The statistics used in this study were means, standard deviation (S.D.) and t-test. The study's findings revealed that graduate diploma in teaching profession students had a high level of instructional media creativity, and their learning achievement after learning through video was significantly higher than before learning.**

Keywords*— *Creating Instructional Media, Video Learning, Social Media Platforms

I. INTRODUCTION

The use of video for teaching and learning has been one of the most popular ways of teaching through the media until now, especially during the COVID-19 outbreak. Teaching styles and instructional models have been changed from classroom learning to online learning [1]. Therefore, teaching through video plays a more important role in learning and teaching. In addition, video is an instructional material that people could create more easily due to the easier production process than the original analog system that has to be recorded in a videotape format and has some tools to edit the system, and the use of analog is quite complicated. At present, video production is digitized with a production process through video cameras, cameras, smartphones, or tablets to record and film. This can record both image animation and digital audio [3] [4] [5]. After recording the video, the data can be edited with computer programs and applications that can be adjusted in colors, fonts, backgrounds, animations, sounds, and add more videos. Furthermore, a large number of computer programs and applications for video editing are quite easy to use and available for people to use [6] [7]. The publishing of the videos through social media platforms to share videos was useful for students who can learn by themselves in this digital age. Moreover, the students could get the information from a video sharing platform to practice, keep the important information to do their reports or do their homework. There are many video learning opportunities on social media platforms such as YouTube, TikTok, Facebook, and 4shared. Students could study through various platforms that can be published via a website or application with electronic communication devices anywhere and anytime. They can repeat the study as many times as they want. [8] [9] [10]. The videos can be produced by the teachers themselves or many videos are available on today's social media platforms and assigned to the students to self-study through the videos. It is a process of supporting self-learning. It focused on students' centers for distance learning or e-learning [11] [12].

Some videos available on social media platforms relate to teaching and learning in many fields. Students could learn many subjects by themselves, such as English, math, and sciences. [13] [14]. Learning through video is important to students, especially students in the Faculty of Education. The content of this video identifies the production of teaching materials, starting with basic teaching materials such as paper, picture cards, word cards, storybooks, pop-up books, and big books. The digital media are e-books, computer-assisted instruction, multimedia, and learning objects. These videos may assist students in learning and producing their own productions in teaching materials more quickly and diversely [15] [16]. Instructional media is one of the most important components of teaching and learning management. University students could develop their media for teaching and learning because it could

communicate some stories, meaning, and content from teachers to students. It could help students learn something difficult or abstract to be easier to understand and more concrete. Instructional media creativity is one of the most important tools in teaching and learning management for educational students[17][18] [19], Especially for students pursuing a graduate diploma in teaching. There are some teachers who have not graduated from the faculty of education. It is necessary for them to learn how to produce instructional media in order to increase their potential, competence, and ability to become a professional teacher. Hence, supporting the ability to create instructional media for graduate diploma in teaching profession students should be considered [20] [21]. According to the epidemic of COVID-19, management of teaching and learning about the production of teaching materials had to change from the classroom into online learning, and the teacher had to adjust the way of teaching. At the beginning of changing the style of teaching, some students couldn't create their instructional media, and the lack of video in teaching to create instructional media is a problem for researchers. As a result, the researcher conducted the research to study how video on social media affects the instructional media creativity of graduate diploma in teaching profession students to develop their ability to create their own instructional media for the students in their schools.

RESEARCH OBJECTIVES

1. To study the ability to create instructional media of graduate diploma in teaching profession students.

2. To compare learning achievement after learning through video learning on social media platforms of graduate diploma in teaching profession students.

II. METHODOLOGY

1. The population of this research was 3 classes of the graduate diploma in teaching profession students who enrolled in the Innovation and Information Technology Course for Educational Communication. Random sampling was used in this study. The sample of this study was 29 graduate diploma in teaching profession students from class 2.

2. The limitation of this study was that the instructional media that the students produced in this research consisted of e-books, and the social media platforms used in this study were YouTube and Facebook.

3. The research instruments used in the research were videos on social media platforms, a media-creating competency evaluation form, and a test. The instruments were assessed by the Index of Item-objective Congruence (IOC) by experts and the mean IOC score was 0.67-1. The students tried out the research instruments with non-sampling students. The reliability of learning achievement test was 0.80.

4. This research is experimental research and the researcher collected the data in semester 2/2019. The data analysis was conducted by the evaluation of the ability to create instructional media with a 5-level scale as follows::

5 means that students' ability to create instructional media was at the highest level.
4 means that students' ability to create instructional media was at high level.
3 means that students' ability to create instructional media was at fair level.
2 means that students' ability to create instructional media was at quite low level.
1 means that students' ability to create instructional media was at low level.

The statistics used in this study to evaluate the ability to create instructional media for graduate diploma in teaching profession students were means and standard deviation. The criteria are as follows:

4.50-5.00 means that the students have the ability to create instructional media at the highest level.
3.50-4.49 means that the students have the ability to create instructional media at high level.
2.50-3.49 means that the students have the ability to create instructional media at fair level.
1.50-2.49 means that the students have the ability to create instructional media at quite poor level
1.00-1.49 means that the students have the ability to create instructional media at poor level

In this study, videos of learning through YouTube and Facebook were provided for the students. Both the teacher and the students learned through these videos in the classroom, and students could learn by themselves anywhere and anytime. In addition, the teacher assigned them to study the videos before class and did some activities in the class.

The researcher got the scores from student achievement tests and analyzed the data by taking the arithmetic means and standard deviation and comparing learning achievement before and after learning by using a t-test.

III. RESULTS

TABLE 1: The ability to create instructional media of graduate diploma in teaching profession students

Factors	$\overline{X}$	S.D.	Range
Content Content analysis for e-book production	3.65	0.61	High
Chapter number division	3.75	0.78	High
Appropriateness of content in each chapter	3.37	0.49	Medium
Content accuracy	4.03	0.73	High
Design Storyboard design	4.34	0.55	High
Purposes design	4.58	0.50	Highest
E-book cover design	4.13	0.74	High
E-book design	3.89	0.72	High
Font design	4.06	0.59	High

Illustration design	4.24	0.68	High
Template design	3.82	0.75	High
Background design	4.13	0.74	High
Color design	4.20	0.67	High
Sound effect	3.79	0.77	High
Test	3.93	0.59	High
Average	4.00	0.66	High

The results from Table 1 have shown that the ability to create instructional media for graduate diploma in teaching profession students was at a high level and the average was 4.00. The S.D. was 0.66. The highest mean was for purposes design. The average was 4.58 and S.D was 0.50, whereas for story board design, the average was 4.34 and S.D was 0.55, respectively.

TABLE 2: The comparison of learning achievement before and after using video learning on social media platforms

Experimental Group	n	Full score	$\overline{X}$	S.D.	t	Sig
Pre-Test	29	30	17.97	2.37	19.13	0.00
Post-Test	29	30	23.93	2.07		

The results from Table 2 showed the comparison of learning achievement before and after using video learning on social media platforms. The result of this study has been that learning achievement from the students after using video learning on social media platforms was higher at a statistical level of.05.

IV. DISSCUSSION AND CONCLUSION

The results of the study of the ability to create instructional media for graduate diploma in teaching profession students was at a high level and the average was 4.00. The S.D. was 0.66. The highest mean was for purposes design. The average was 4.58 and S.D was 0.50, whereas for story board design, the average was 4.34 and S.D was 0.55, respectively. The results of the study could imply that video learning on social media platforms could improve the ability to create instructional media for students. The findings of the study by Clerkin and et al (2022) [22] showed that video was impact teaching methodology on achieving psychomotor skills in nursing students and learning achievement. The advantage of video teaching was that it was convenient and easy to access the content through smartphones. It could help the students practice themselves and develop their skills and knowledge all the time. The study of Paratore et al. (2016) [23] indicated that the use of video and social media was useful to support the development of knowledge and skills for preservice teachers in reading. The results from Mustofa and et al. (2022) [24] found that movie learning through video has an effect on the perceptions of the students, and it also improves their awareness because video learning is convenient. According to the related research, it could be concluded that using videos on social media platforms can enhance students' potential.

According to the comparison of learning achievement before and after using video learning on social media platforms, the result of this study has been found to be that the learning achievement of the students after using video learning on social media platforms was higher than before using it. The results of the study are also the same as the study of Fak-On and Chobthamdee (2020) [25], which indicated that learning achievements of the students after using social media and digital video was higher than before using videos. Furthermore, the study of Singhato, BanJong and Charoonruk (2017) [26] showed that learning trough Video improve students' knowledge at statistically significance. It could be implied from the related studies that video learning affects learning achievement at a higher level with statistical significance.

RECOMMENDATIONS

1. This research could be used as a guideline in video learning on social media platforms. Researchers who are interested in using video should learn how to use video and prepare for the media in teaching.

2. Video learning on social media platforms should be applied to other subjects such as English, math, or sciences in order to develop the quality of education and improve students.

3. Primary school students, high school students, or university students could have the opportunity to use video learning on social media platforms in order to confirm that learning through video on social platforms could develop students at all levels.

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Engineering Education Roadmap of the Future Trend of Basic Metaverse based on VR with cooperation between the government and the private sector

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Abstract

This article presents an educational roadmap of future trends of Metaverse in VR-based by collaborating between the School of Engineering, King Mongkut's Institute of Technology Ladkrabang (KMITL) with iMAKE company to make a part-time learning plan. The objectives were to measure the achievement and evaluate satisfaction with the development of part-time learning skills in technology on the topic "Basic Metaverse based on VR". The sample group was students in a double-degree bachelor's degree program (Dual Degree) between the School of Engineering and the Faculty of Science, KMITL: Bachelor of Engineering (IoT System and Information Engineering) and Bachelor of Science (Industrial Physics) for 16 students by selecting a specific sample group, the engineering education program has a systematic process. The results showed that the achievement of part-time learning skills development in technology on the topic "Basic Metaverse based on VR" higher than the set criteria 74%, the overall satisfaction is at a very good level, the mean satisfaction was 4.636 and the sample standard deviation was 0.39.

Keywords—Metaverse based, VR, cooperation, and iMAKE

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Engineering Education Roadmap of the Future Trend of Basic Metaverse based on VR with cooperation between the government and the private sector

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***Abstract*— This article presents an educational roadmap of future trends of Metaverse in VR-based by collaborating between the School of Engineering, King Mongkut's Institute of Technology Ladkrabang (KMITL) with iMAKE company to make a part-time learning plan. The objectives were to measure the achievement and evaluate satisfaction with the development of part-time learning skills in technology on the topic "Basic Metaverse based on VR". The sample group was students in a double-degree bachelor's degree program (Dual Degree) between the School of Engineering and the Faculty of Science, KMITL: Bachelor of Engineering (IoT System and Information Engineering) and Bachelor of Science (Industrial Physics) for 16 students by selecting a specific sample group, the engineering education program has a systematic process. The results showed that the achievement of part-time learning skills development in technology on the topic "Basic Metaverse based on VR" higher than the set criteria 74%, the overall satisfaction is at a very good level, the mean satisfaction was 4.636 and the sample standard deviation was 0.39.**

Keywords*— Metaverse based, VR, cooperation, and iMAKE

I. INTRODUCTION

Nowadays, technology in the digital age is evolving rapidly, Nowadays, technology in the digital age is evolving rapidly to meet users with a variety of age differences, including childhood, adolescence, working age, post-worker age, and the elderly, the demand is constantly increasing. For technology users to get to know, learn and use new technologies to facilitate life to be comfortable, reduce time, reduce energy, reduce expenses, etc. and with the epidemic situation of the COVID-19 spreading around the world, it is a driving force for various technologies, it has been developed to have a higher level of intelligence and create new innovations and technology to support a comfortable life in the future which from now on life will change rapidly. Preparing to access digital technology knowledge is necessary for users of all ages, especially young people, in order to create technology to respond to technology users in a local context and that country. Before the epidemic, the education system relied on on-site teaching, but in the past two years, the education system has been affected by the COVID-19 pandemic. Teaching is online and adjust to a hybrid according to the epidemic situation. It is the overall policy of the country that is mutually accepted. However, both online and hybrid teaching may result in the failure of learning to develop students in all three areas according to Bloom taxonomy learning theory. (classify learning objectives into 3 areas including Cognitive Domain, Psychomotor Domain, and Affective Domain) [1] Each university has to find strategies and methods to ensure that teaching and learning are consistent with the mechanisms continuously such as Rajamangala University of Technology Suvarnabhumi, Electronic Engineering and Telecommunications Engineering Course, School of Engineering and Faculty of Architecture offers learning in epidemic situations by delivering materials and learning materials to students for hands-on

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learning online, with a very good overall satisfaction level. [2] From the guidelines for managing the equipment to be within the same board. [3] King Mongkut's Institute of Technology Ladkrabang, Information Engineering course, School of Engineering has introduced a hybrid approach to teaching and learning. There was a good overall level of satisfaction. [4] From the severe situation, the teaching policy has been loosened to be in accordance with the teacher's agreement with the learners in the teaching method. With such a situation occurring, it is necessary to plan and adapt to accommodate and access new technologies, but with the policy driven, each university remains unable to keep up with the rapid changes in technology coupled with the rigor of regulatory oversight, restricted regulations and scope of driving. [5] This greatly affects the development of technology, compared to the private sector, which has streamlined operations in terms of budget, time, materials and personnel, it results in faster development. With the aforementioned limitations, it may result in the technology teaching of youth not being in line with modern technology, one solution to this problem is cooperation or funding from external agencies that are ready to support modern learning.

From the reasons mentioned above Therefore, the researcher has foreseen some problems that affect the development of technology and teaching skills in the post-COVID era, this approach has resulted in educational development by presenting an engineering education roadmap of the future trends of Metaverse. Based on VR with public-private partnerships, presenting learning management in digital technology based on MOUs with the private sector between the School of Engineering, King Mongkut's Institute of Technology Ladkrabang with iMAKE company make a part-time learning plan on the topic "Basic Metaverse based on VR" in basic to students in a double bachelor's degree program (Dual Degree) between the School of Engineering and the Faculty of Science, King Mongkut's Institute of Technology Ladkrabang, Bachelor of Engineering (IoT System and Information Engineering) and Bachelor of Science (Industrial Physics) to prepare students with a technological foundation to gain new perspectives based on their own creative imaginations, practice to inspire and to develop self-skills under the topic "Basic Metaverse based on VR".

II. RELATED THEORIES

Metaverse (an imaginary universe) is probably defined as a vast, non-existent space (virtual world) that can (but) be created [Three-dimensional (3D): VR] or mixed with the real world (AR) and can be integrated into an experience with others by using digital technologies such as Blockchain, things in the virtual world are tangible or proprietary until becoming a digital asset that is in the virtual world and can bring digital assets back to the real world.

III. RESEARCH OBJECTIVE

1. To measure the learning outcomes, the development of part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of students after learning management.
2. To evaluate satisfaction with the development of part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of students after learning management.

IV. RESEARCH HYPOTHESIS

1 . Outcomes of developing part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of the students are in the criteria of not less than 70%

2 . The results of the satisfaction evaluation on the development of part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of students is in good level.

V. METHODOLOGY

This research is experimental research to measure learning outcomes and assess satisfaction with developing part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of students in double bachelor's degree programs (Dual Degree) between the School of Engineering and the Faculty of Science, KMITL: Bachelor of Engineering (IoT System and Information Engineering) and Bachelor of Science (Industrial Physics) have followed the steps shown in Fig. 1

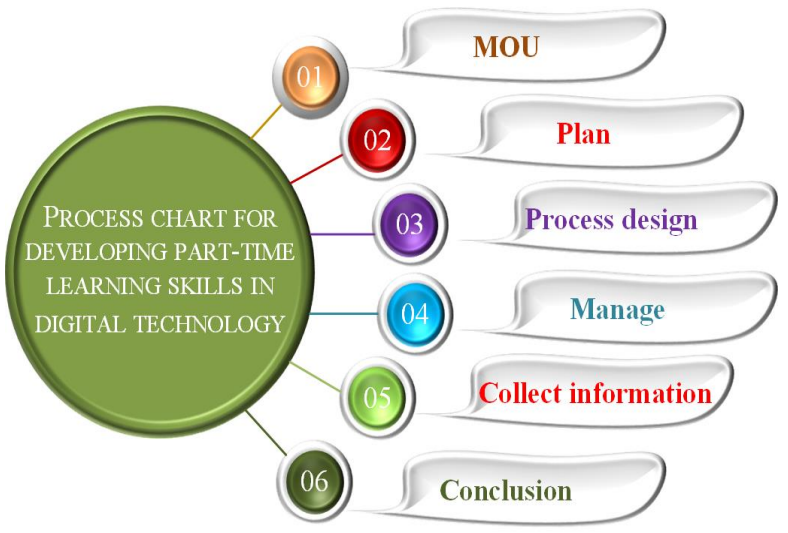

Fig. 1. Process chart for developing part-time learning skills in digital technology

From the first chart shows the process of learning management, which has the following steps:

1. Cooperation between the School of Engineering, King Mongkut's Institute of Technology Ladkrabang (KMITL) with the private sector is iMAKE company on October 11, 2021 at the School of Engineering, KMITL.

Fig. 2. Making the agreement between the School of Engineering, KMITL with the private sector iMAKE company

2.Plan a joint action plan for both sides to develop part-time learning skills in digital technology on the topic "Basic Metaverse based on VR". This step is a joint meeting between the instructors in charge of both courses with iMAKE Company as shown in Fig.3

Fig. 3. Planning meeting for both parties

3. Design a process for developing skills for part-time learning in digital technology on the topic "Basic Metaverse based on VR" has been processed as follows:

3.1 Participate in meetings and present general issues of the dual degree program.

3.2 Consider the issues together.

3.3 Seeking ways to develop skills in digital technology.

3.4 Bring all information to analyze to get a conclusion as shown in Fig. 4.

Fig. 4. Meeting to jointly design the process of developing part-time learning skills in digital technology

4. Operation method

4.1 Determine the population and the sample

The target population is student from Bachelor of Science (Industrial Physics), School of Engineering, KMITL.

The sample group used in this research was second year undergraduate students, academic year 2022 in Bachelor of Science Program in Industrial Physics, Faculty of Science, KMITL who interested in studying a double degree program by selecting a specific sample of 16 people.

4.2 Tools

A test to measure the development of part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of students for 14 items.

The satisfaction evaluation form for the development of part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of students for 6 topics.

4.3 Creation and quality inspection of tools

-Design of a test to measure the achievement of the development of part-time learning skills in digital technology on the topic "Basic Metaverse based on VR" of the students was a multiple choice of 14 items that passed the evaluation of conformity between the objectives and knowledge (IOC) from 3 experts.

-Design a satisfaction evaluation on the development of part-time learning skills in technology on the topic "Basic Metaverse based on VR" of students.

4.4 Manage and collect information as shown in Fig. 5

From the Fig.5 shows the operations and data collection as follows:

1. Open for applications for students applying to develop part-time learning skills in technology on the topic "Basic Metaverse based on VR" voluntary.

2. Student orientation to understand students towards participating in this skill development.

3. Students enter the system for developing part-time learning skills in technology on the topic "Basic Metaverse based on VR", it took 3 hours to develop skills on April 2, 2022 at iMAKE Company, Bangkok Shown as shown in Fig. 6.

4. When students complete the development of part-time technology learning skills on the topic "Basic Metaverse based on VR" take a test to measure the development of part-time learning skills in technology on

the topic "Basic Metaverse based on VR" for 1 4 items and evaluated the satisfaction of developing part-time learning skills in technology on the topic "Basic Metaverse based on VR" for 6 topics.

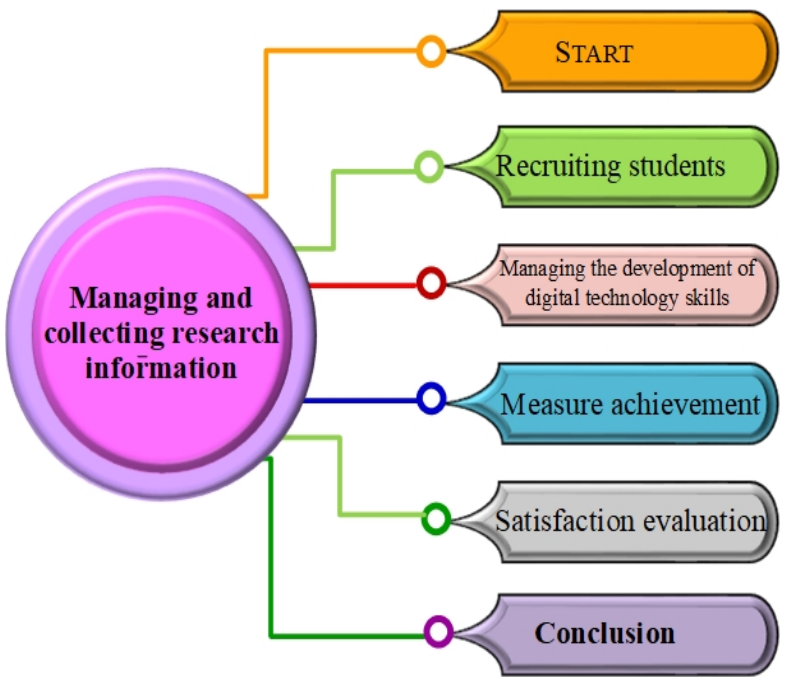

Fig. 5. Managing and collecting research information

VI. Results And Discussion

After completing the part-time technology learning skills development on the topic "Basic Metaverse based on VR", have conducted measurements and inquired about student satisfaction who were a sample group of 16 people, the results are summarized as in Table 1 and Table 2 as follows:

Table 1. The results of the test to measure the development of skills for part-time learning in technology on the topic "Basic Metaverse based on VR"

Measurement test	N	Full score	ΣX	$\overline{X}$	Percentage
14 items	16	14	165	10.31	74

Fig. 6. Implementation of part-time learning skills development in technology

Table 2 Satisfaction effect on the development of part-time learning skills in technology on the topic "Basic Metaverse based on VR".

satisfaction issues	Σ	N	$\overline{X}$	S.D.	Interpretation
1.Developing part-time learning skills	74	16	4.625	0.50	Very good
2.The knowledge gained can be applied to a project.	65	16	4.063	0.25	good
3.Lecturers for developing part-time learning skills have knowledge and abilities	77	16	4.813	0.25	Very good
4.Days and times for developing part-time learning skills be appropriate	79	16	4.938	0.25	Very good
5.The place for developing part-time learning skills is ready	74	16	4.625	0.50	Very good
6.Get the Benefit from developing part-time learning skills	76	16	4.750	0.45	Very good
Total			4.636	0.39	Very good

From Table 2 , the satisfaction results of the development of part-time learning skills in technology on the topic "Basic Metaverse based on VR" Overall, they were the most satisfied. The mean satisfaction was 4.636 and the sample standard deviation was 0.39.

VII. Conclusion

This article presents an engineering education roadmap of the future trends of the VR-based Metaverse through public-private partnerships by organizing the development of part-time learning skills in technology on the topic "Basic Metaverse based on VR" for 16 students, the test results of the 16 samples were 74% higher than the set criteria and were satisfied with the most overall, their average satisfaction was 4.636 with a standard deviation of 0.39.

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A Design and Development of Internet of Things (IoT) System and Learning Activity to Promote Computational Thinking

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Abstract

Computational Thinking (CT), problem- solving and programming skills are important for the students with major of computer education of higher levels education which related to the computing science contents. The instructions must provide the basic contents and learning activities, including Internet of Things (IoT), big-data and programming, as well as Artificial Intelligence (AI) and machine learning. However, these courses present learning difficulties based upon the students' individual skills. Development and integration of the IoT system would offer supporting tools for learning activities and improve the students' computational thinking, problem-solving, and programming skills. This paper presents the design and development of IoT system to support students' computational thinking, problem-solving, and programming

skills training through block-based programming and integrated platforms. The IoT system comprises three layers (hardware, middleware, and applications), using existing platforms and devices as well as newly developed. To validate the viability of the proposed pipelined realization, the developed systems were implemented for higher education level students of computer education program. The students' computational-thinking, problem-solving, and programming skills were significantly improved through the proposed learning system throughout the course.

Keywords—computing skills, computational thinking, problem solving, Internet of Things, computer programming

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A Design and Development of Internet of Things (IoT) System and Learning Activity to Promote Computational Thinking

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Keywords—computing skills, computational thinking, problem solving, Internet of Things, computer programming

I. INTRODUCTION

Computational Thinking (CT) has become renewed interest in both elementary and higher education research in recent years [1], as it is considered to an important abilities of the 21st century, developing global citizens in this era of the disruptive technologies [2]. The augmentation of emerging digital technologies involving practical big-data utilization, such as Artificial Intelligence (AI) and machine learning requires competencies for manipulation, usability, and adaptability. CT not only supports programming skills development but also provides a sustaining tool to reach the desired achievement in the problem-solving. In contrast, learning and practice in programming may improve CT abilities. However, it is still difficult to enhance the students' computational thinking skills through the context of teaching programming. Because CT is the pathway in general problem-solving in real-world situations, programming relies on a student's specific skills in systematic and logical thinking. Some students may be constricted by the burden of implementing a significant amount of code to create successful programs within these complex processes.

Current programming instruction involves both software and hardware components acting as engagement tools between learners and such abstract contents. The software components include programming languages, which are introduced as a teaching tool in a form of block-based commands. In the hardware component, several smart embedded devices are produced to support programming. These devices are also appropriate with the IoT projects development leading to the understandings of sufficient machine-learning utilization. Therefore, the implementation of IoT equipped with AI and machine learning systems present the primary scheme necessary to take advantage of this occurrence.

This paper presents a system for the instruction of IoT and programming to enhance CT through simulated problem situations. The system is designed in conjunction with various related systems and components. At the bottom layer of the architecture, the hardware layer includes the embedded computing board or microcontroller board, as well as other compatible electronic devices. The middleware layer is designed to maintain the collected big-data gathered from the hardware and handle the communication between the hardware and the applications within the cloud servers. The top application layer of the architecture provides web-based applications coping via the learning activities management tools related to programming of the IoT devices. Moreover, the system also provides the flexibility to further extend applications to support AI and machine learning study. To validate the viability of the proposed pipelined realization, the developed systems were education, to study CT abilities within the target group through an authentic class in a single semester. The experiment results showed that students' CT level was adequate and that they could accomplish problem-solving task through the proposed system.

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TABLE I. COMPUTING SCIENCE & IOT TEACHING TOOLS

Tools	Features			Summary
	3D/Sim.	***IoT/HW***	***AI-ML***	
LEGO	External simulator	Robots (EV3)	-	Lego® is graphical programming that combines building with the familiar Lego bricks, using easy-to-use coding software, and making coding fun with the robot.
MIT's Scratch	Built-in 2D simulator	MCU board & Robots (MicroBIT, LEGO EV3)	Extension blocks (Computer Vision)	Scratch [3] is an online visual programming language developed by MIT Media Lab. Users can create sprite objects and make them animated through command blocks. Using the extension blocks, Scratch can also control various IoT hardware; such as MicroBIT, LEGO's EV3, etc.
Tinkercad	3D / built-in simulator	MCU board (Arduino)	-	Tinkercad is a cloud-based software that provides applications to learn the basics of designing the circuits and programming with Arduino® boards, as well as building 3D-models through the command blocks.
Makecode	Built-in 2D simulator	MicroBIT	-	MicroBIT® is a product of BBC which is developed for being the most simple and effective learning tool for coding, digital, and creativity skills through an electronic board. Within the Makecode platform, the learner can create the interesting projects and can share them with others.
KidBright IDE	Built-in 2D simulator	KidBright	Extension blocks (ML-Block)	KidBright® is an integrated electronic device, IoT platform based on ESP32 MCU chip. As a device used as a tool for coding and CT learning in schools. Students are available to build a program using the KidBright IDE and upload into the hardware directly.

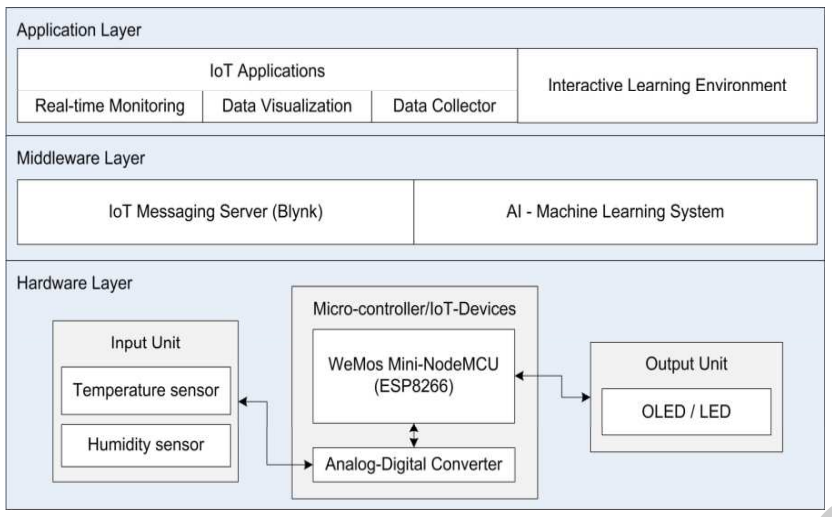

Fig. 1. Three layers of IoT system architecture.

II. LITERATURE REVIEWS

CT teaching tools focused upon within this paper represent programming tools suitable for teaching strategies that facilitate the coding, debugging execution, and monitoring of the results. Many tools provide more advanced features, such as connecting the microcontroller and IoT devices, robot programming, and hardware simulations. Table I presents a list of programming-teaching tools often used for promoting CT. Several recent studies have implemented such tools to enhance the students' CT and programming abilities. Gerber et al. [4] studied on utilization of LEGO robot in STEM education. Another studies; such as Rodriguez-Martinez et al. [5] utilized Scratch as a programming environment to study students' computational thinking. Abburi et al. [6] proposed a virtual labs approach using TinkerCad as a simulation tool for the instruction. In addition, Jailungka et. al. [7] proposed an augmented reality system in conjunction with Microbit to support the project-based learning.

III. SYSTEM ARCHITECTURE & DEVELOPMENT

The architecture of the IoT system, described in this section, consists of three layers: 1) hardware layer, 2) middleware layer, and 3) application layer, as shown in Figure 1.

A. Hardware Layer

In this layer, the micro-controller/IoT devices are designed as primary data collector equipment in the IoT system. This research incorporated a newly designed mainboard to connect with a low-cost microcontroller board and other various electronic modules. Students can further their basic skills of electronic wiring and connect through simple jumping or plugging of the wired pin headers. The mainboard employed to integrate the IoT devices (i.e., WiFi microcontroller board, OLED, input sensor modules, etc.) was newly designed and produced within this study. Its design is compatible with the compact, low-cost MCU board (Wemos D1-mini), which was based on the ESP8266 WiFi-support chip [8], necessary to make an internet connection. The purpose of developing a new mainboard was to provide a simpler connection with the related devices through the pin headers. As shown in Figure 2 (a-b), the schematic of the mainboard's circuitry was initially built from the MCU board socket, which was designed as a 16-pin (2.54 mm pin spacing) connector. Pin-connectors from other modules were then wired through the circuit connecting to the MCU board socket. The OLED can be connected directly to the mainboard through a 4-pin socket (H6), which has circuit-wiring to the MCU board via the I2C interface (pins GND, 5V, D2, and D1). The H3 pins were also designed to connect to the analog-to-digital converter module (ADS1115), which also requires an I2C interface in an address different from the OLED module, thereby enhancing the analog input/output connection of the MCU. (Notably, the analog-pin of the Wemos D1-mini contains only one A0 analog pin). Lastly, the remaining digital input/output pins of the MCU board were expanded into the pins-header slots for cable jumping with screw-sockets to further aid in the connection with the external modules. The images of real device; consisting of the mainboard combined with the MCU board, OLED, input sensor, and external LED module are shown in Figure 2 (c-d), respectively.

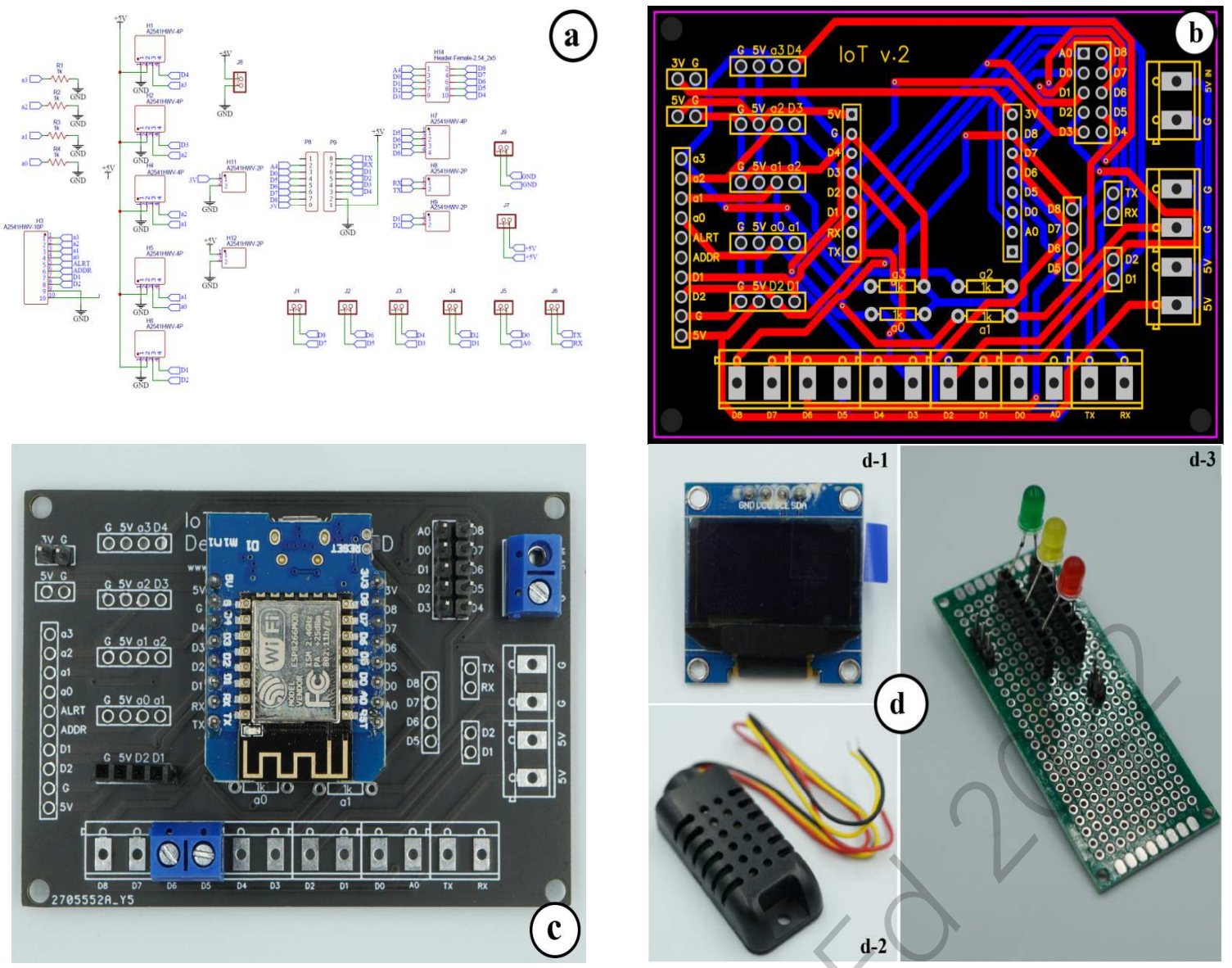

Fig. 2. (a) IoT mainboard's designed circuit schematic, (b) PCB diagram, (c) MCU board combined with mainboard, and (d) Input/Output devices including; (d-1) OLED, (d-2) temperature-humidity sensor, and (d-3) LED module.

B. Middleware Layer

This layer contains two main cloud servers. The IoT server facilitates the data store services derived from the messaging protocol of the IoT devices using Blynk platform. The AI-machine learning system developed with python would further utilize the primary data stored in the IoT server with various aspects of machine learning algorithm. Various types of machine learning algorithms were provided into the web-based API, employing several existing libraries, such as NumPy, ScikitLearn, and Pandas.

C. Application Layer

The IoT applications are provided to manipulate real time and time series data that are stored in the IoT message system (Figure 3). The interactive learning environment provides the basic services of a learning management system. Visual programming (Figure 4) also facilitates a graphical programming platform that can support users by creating a simple commands for the IoT devices through the blocks programming tool.

IV. Implmentation & Experiment Results

In this research, the systems we designed and developed were implemented in an authentic class entitled: Application Programming for Education. The experiment was conducted with first-year under-graduate students of computer education program in academic year 2021. The 58 participants consisted of 44 male and 14 female students. The experiment herein primarily utilized the students' feedback generated during classroom activities in conjunction with previous theoretical framework on CT assessments. To manipulate the classroom into the developed system, the learning activities were designed into following steps:

1. The problem statement defines the students' tasks and requirements at the start of the class;
2. Students analyze the assigned problem to deconstruct the tasks and requirements into smaller parts (decomposition);
3. A systematic explanation of possible solutions is drawn by students to describe their abstraction of the problem to be solved (abstraction);
4. Students search and collect command blocks related to the solution (pattern recognition), inferred from Step 3;
5. The algorithms are synthesized by students according to their conceptual design and collected blocks (algorithm design);
6. Students verify and debug their algorithms by uploading and executing their command blocks into the IoT hardware.

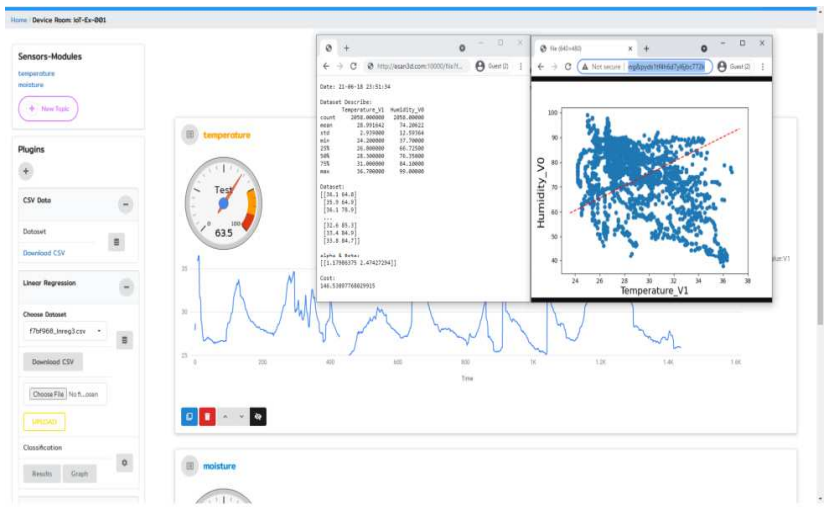

Fig. 3. IoT monitoring application and data visualization.

TABLE II. COMPUTATIONAL THINKING & PROGRAMMING ASSESSMENT CRITERIA

Activities	**CT criteria (Rubric)**			
	Decomposition	***Abstraction***	***Pattern Recognition***	***Algorithm Design***
AC1: Building a program to control the IoT device to display on/off signal (LED) in an infinite pattern with stable tempo.	Describe the components of the assigned tasks in groups; such as input, output, and processing; evaluated through a four-level score (1-4): 1 - No component is correct; 2 - Few components are correct; 3 - Few components are missing; 4 - Completed all components with general concept grouping.	Describe the ideas behind the problem-solving approach to the assigned tasks and represent it either a graph or diagram; scored at Levels 1-4: 1 - No description related to the task; 2 - Few aspects related to the task; 3 - Most of aspects related to the task; 4 - All aspects related to the task.	Select appropriate command blocks according to the abstraction to complete the assigned task; scored at Levels 1-4: 1 - no commands are correct; 2 - Few commands are correct; 3 - Few commands are missing; 4 - Completed all commands.	Arrange the command blocks to complete the assigned task; scored at Levels 1-4: 1 - Nothing can run; 2 - Some processes work; 3 – Most of processes work; 4 - All processes work completely with the appropriate arrangement.
AC2: Building a program to control the IoT device to display on/off signal (LED) on-demand of the mobile's application button.				
AC3: Building a program to control the IoT device to display three pattern (LED) signals depending on the mobile's application button.				
AC4: Building a program to control the IoT device to display the temperature and humidity for sensors to the mobile's application and store the data in the IoT storage.				
AC5: Design a program to control the IoT device to display on/off (LED) every two seconds, infinitely.				
AC6: Design a program to control the IoT device to display on/off (LED) dealing with the temperature conditions with the start/stop button of the mobile application.				

Rubric scores' levels and percentage: Lv1 – Needs Improvement = 60%, Lv2 – Satisfactory = 73%, Lv3 – Good = 87%, Lv4 – Accomplished = 100%

TABLE III. STUDENT'S COMPUTATIONAL THINKING RESULTS

CT abilities	**AVG. (%)**	**Freq. Distribution (persons)**			
		Lv4	***Lv3***	***Lv2***	***Lv1***
Decomposition	87.88	2	55	0	1
Abstraction	87.62	4	49	4	1
Pattern Recognition	93.79	25	29	3	1
Algorithm Design	91.82	16	30	11	1

Table II explains CT assessment criteria (rubric) in four abilities: decomposition; abstraction; pattern recognition; and algorithm design, of six classroom activities (AC1-AC6). Figure 4 demonstrates a student's feedback of algorithm design (Step 5), which the teacher then evaluates through the CT attributes. The experiment results, Table III, indicate an overall student CT average of 91.02%, based on the rubric scores of both the student feedback of their participation in the classroom activities and their paper-based final examinations. Regarding the individual thinking abilities of CT, pattern recognition obtained the highest score of 93.79%, whereas algorithm design, decomposition, and abstraction scored 91.82%, 87.88%, and 87.62%, respectively.

V. CONCLUSION

This paper presents a fully pipelined architecture of the supporting tools required in the teaching and learning activities in subjects related to computing science contents, such as programming, IoT, big-data, and AI-machine learning. In the development of our proposed system, several systems were utilized and deployed locally in our research. While we have presented a complete set of related tools in our study, there are still many other similar tools. Instructors should choose any available tools, though not presented herein, which are most suitable to their needs.

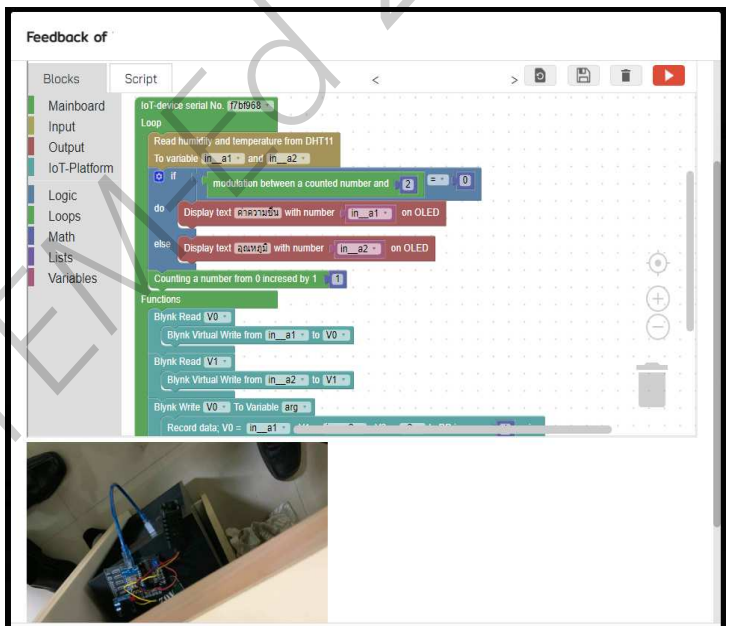

Fig. 4. An example of student's feedback in the algorithm design.

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Outcome-based Learning in Online STEM Activities for Robot and Real Estate Management Camp

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Abstract

This paper presents the outcome-based learning STEM online activities for the robot & real estate and facility management camp (R^2 Camp) in order to develop the soft skills within knowledge management. The main objective is to provide knowledge on the real estate & facility management, the robotics engineering and how to apply robotics application to the real estate management, which can inspire young people to study in the robotics engineering and real estate & facility management. There are two sections of STEM online activities as: 1) Fundamental of real estate management and robotics engineering, 2) Robotics application in the real estate management. Pre-test and Post-test about the both fundamental

are used for outcome-based assessment. Results show that learners' outcomes can achieve the basic knowledge by 10.4%.

Keywords—Outcome-based Learning (OBL), STEM, robot, real estate and facility management, R^2 camp

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***Abstract*—This paper presents the outcome-based learning STEM online activities for the robot & real estate and facility management camp (R^2 Camp) in order to develop the soft skills within knowledge management. The main objective is to provide knowledge on the real estate & facility management, the robotics engineering and how to apply robotics application to the real estate management, which can inspire young people to study in the robotics engineering and real estate & facility management. There are two sections of STEM online activities as: 1) Fundamental of real estate management and robotics engineering, 2) Robotics application in the real estate management. Pre-test and Post-test about the both fundamental are used for outcome-based assessment. Results show that learners' outcomes can achieve the basic knowledge by 10.4%.**

***Keywords*—Outcome-based Learning (OBL), STEM, robot, real estate and facility management, R^2 camp.**

I. Introduction

The science, technology, engineering, math (STEM) is a dominant concept of education in this constantly evolving world [1]. There are several STEM have been researched in [2], [3], [4] based on advanced technology for improvement the learning abilities. According to [5], there are four successful soft skills in STEM which are required the ability to adapt and change, a commitment to lifelong learning, good communications skills, and creative thinking for the 21st century skills.

Robotics plays an important role for STEM education, which can help students to engage with these subjects and enjoy the class in the interactive way. Educational robotics cloud assist students acquire the soft skills, such as collaboration. According to [6], another prospective study priority is a factor influencing the effectiveness of innovation contests in developing soft skills, such as an inventive mentality [7]. Inexpensive educational robotics explores the development process of educational robotics to promote STEM learning in [8], and an open-source mobile robot platform called *PlatypOUs* aims at developing a tool for teaching STEM [9].

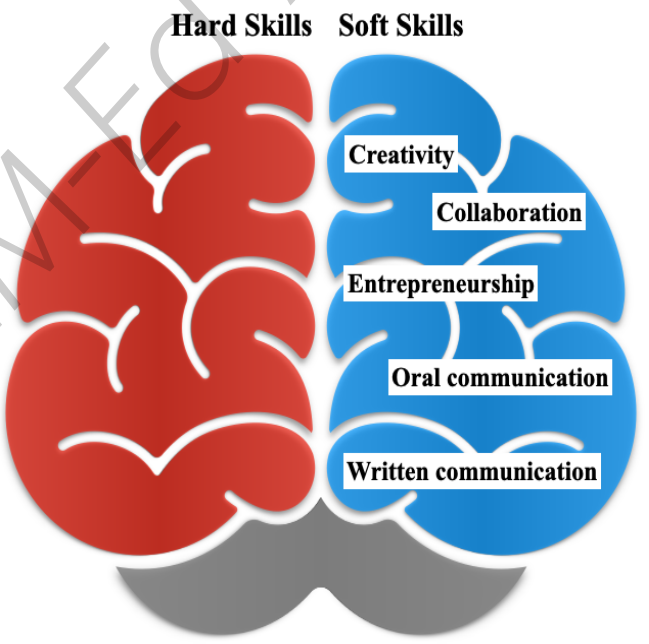

Fig. 1: Soft skills of 21st century skills [10].

This paper presents how R^2 Camp activities can engage with robotics engineering and real estate management, while the demonstration of robotics application in the field of real estate management can motivate to the real world. Moreover, soft skills will intend to improve creativity and eventually prepare students to take on the leadership responsibilities.

The paper is organized as follows: Section II describes the STEM education. Section III provides a brief overview of the R^2 Camp online STEM activities. Section IV describes results. This work is then concluded in section V.

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Fig. 2: The R^2 Camp online registration form with details.

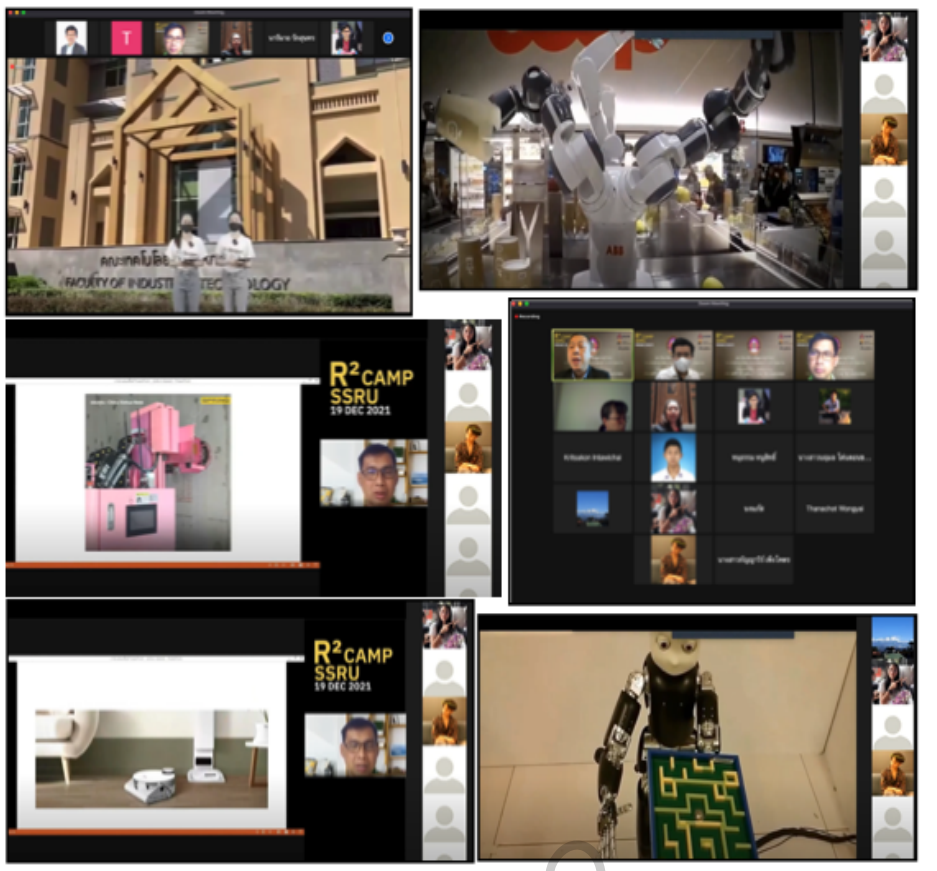

Fig. 3: Content of robotics in R^2 Camp online STEM activities.

II. STEM Education

The goals of STEM education to cultivate the creativity, imagination and global application skills of students [1]. Active learning approaches are highly beneficial for acquiring the 21st century abilities, particularly soft skills [10] as shown in Fig. 1. There are five soft skills as creativity, collaboration, entrepreneurship, oral communication and written communication.

Outcome-based education [4] is a goal-oriented approach with the student-centered education that teacher can design for the learning outcome of course in the lesson plan. Instructor can perform the learning activities using video and slide presentations to endorse their intended learning outcomes at the end of course. The next section demonstrates how soft skills and outcome-based learning are applied in the R^2 Camp's online STEM activities.

III. Proposed R^2 Camp Online STEM Activities

The R^2 Camp online STEM activities are a tool of STEM educational approach that provides learning activities through an online platform as follows.

A. R^2 Camp Promote & Registration

On November 2021, this R^2 Camp began with promote on the Facebook page's department of Robotics Engineering, websites and online registration tool is powered by the Google Forms as illustrated in Fig. 2.

B. R^2 Camp Activities

R^2 Camp started on December 19th, 2021, at Faculty of Industrial Technology, Suan Sunandha Rajabhat University. The high school students registered and loged into the Zoom meeting. Firstly, students must complete the pre-test in 15 minutes before an opening ceremony activity. This camp activities are then split into two main contents as robotics and real estate.

Fig. 4: SANDEE Robot.

The content of robotics is shown in Fig. 3. To lead students develop their knowledge and motivation by using 3D video by robot named "SANDEE" which is shown in Fig. 4. SANDEE is a designed robot for delivery service within the condominium, with alerts via the mobile application. There are two topics of fundamental and robotics applications as:

1) *Topic of design and development of robots*: The speaker explains definition of robotics, different types of robots, robot structures, and how to create and develop the robots. At the end of session is the discussed between students with lecturer and sharing their experiences.
2) *Topic of robotics for home/residences services*: The presenter provides several examples of how the robot can apply in real estate management, home service, cleaning, and washing. The students discussed how they use robot cleaning in their home. This subject is connected to the soft skills.

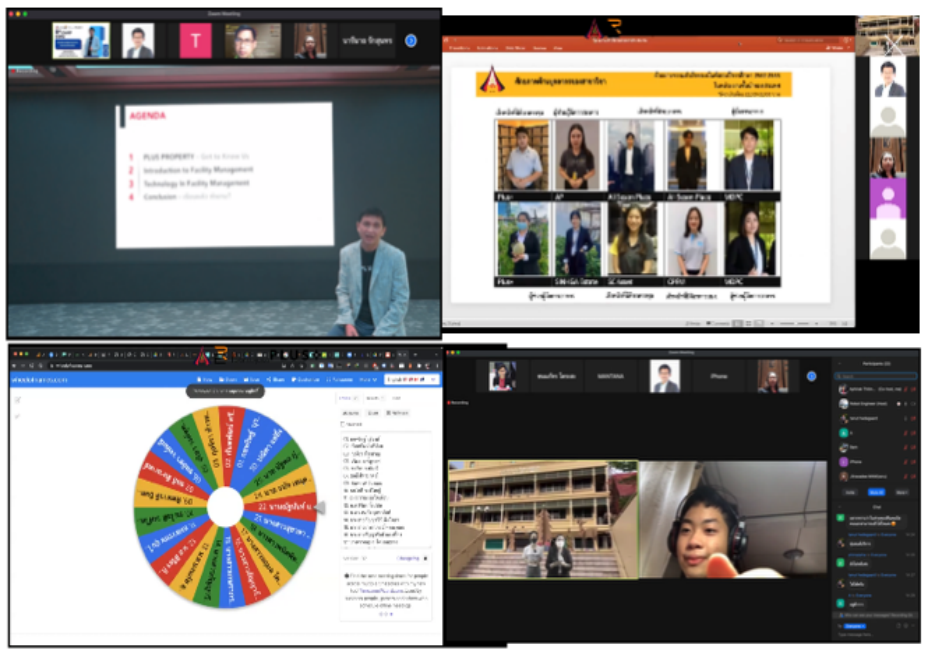

Fig. 5: Content of real estate & facility management in R^2 Camp.

Content of real estate & facility management is presented in the 3D video of SIRI CAMPUS tour illustrated in Fig. 5, facility management will lead students in their knowledge and skills. The SIRI CAMPUS is an example of multifunctional real estate and facilities management. There are two topics of real estate & facility management as:

1) *Overview of plus property & real estate and facility management*: The speaker discusses the Plus Property about an introduction to facility management, facility management technologies, and seven jobs related to facility management. After that, students discussed and informed that they had met with some associated occupations.
2) *Topic of academic achievement of real estate and Facility Management*: The head of department discusses the academic accomplishments of real estate and facilities management, as well as collaborating with prominent enterprises. In this session, students asked the question to the head of department head and senior students on the employee costs, pain points, job pressure and teamwork. After the Q&A session, students played the quiz games for souvenirs, took the post-test, and obtained the certification.

C. Online R^2 Camp Platform

The online R^2 Camp platform illustrated in Fig. 6, is available at *https://rbe.fit.ssru.ac.th*. The platform is organized according to the following:

- The ID for Zoom meeting.
- 2D and 3D video: the SANDEE robot introduction and SIRI CAMPUS tour.
- Speaker I-V presentations have been provided in video.
- A template for 3D glasses is shown in Fig. 7.
- The R^2 Camp activities in video.
- Pre-test & post-test documents for the R^2 Camp assessment and certification are available for download.

Fig. 6: The online R^2 Camp platform.

Fig. 7: Template for 3D glasses.

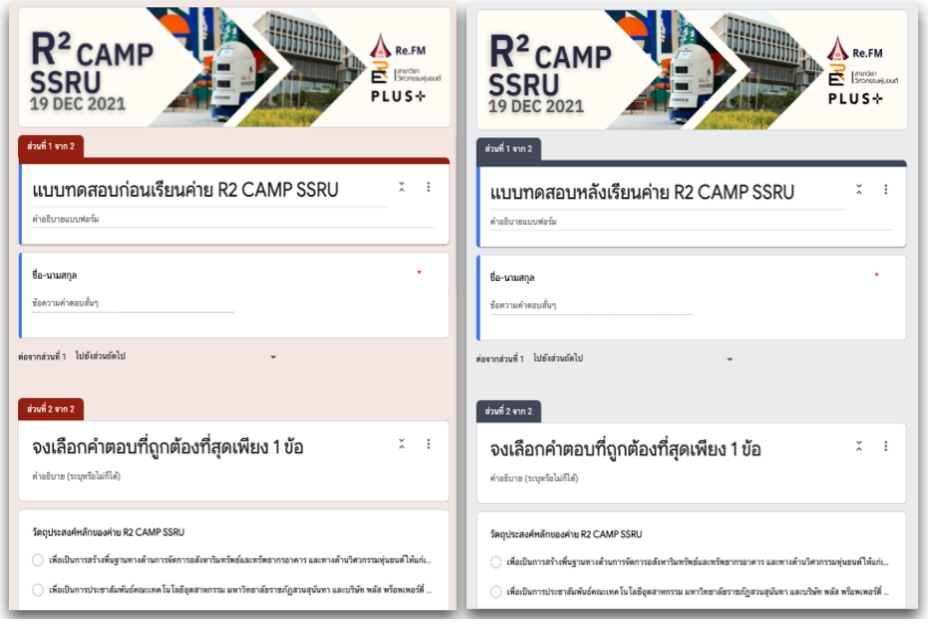

Fig. 8: Pre-test & post-test created by Google Forms.

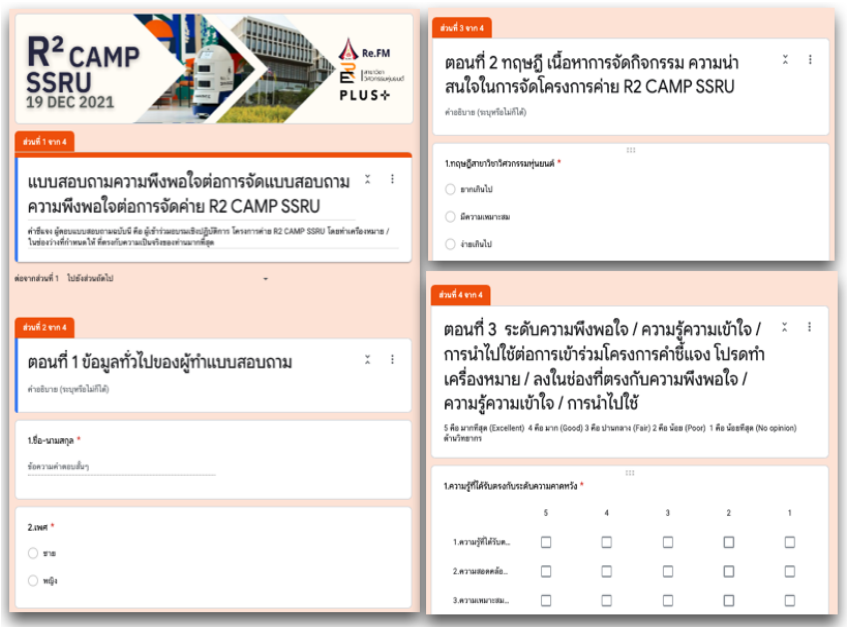

Fig. 9: The satisfaction questionnaire of R^2 Camp.

Fig. 8 depicts a Google Forms of pre-test and post-test of fundamental knowledge in the robotics, real estate and facility management for outcome-based assessment.

IV. Results and Assessment

R^2 Camp online STEM activities were attended by 17 high school students. Table I shows the average pre-test and post-test scores of 2.59 and 3.11, respectively. The maximum score is 5. The students' fundamental knowledge has increased by 10.4%. When the students are working on this camp, they are delighted and have a good experience.

TABLE I: Pre-test and Post-test Scores.

Test	No. of Questions	Average score	S.D.
Pre-test	10	2.59	1.00
Post-test	10	3.11	1.17

The satisfaction questionnaire of R^2 Camp for online STEM activities is designed to measure the students' satisfaction with their learning. This questionnaire will help teachers and organizer of R^2 Camp to understand how satisfied students are and to evaluate and improve the camp as shown in Fig. 9 that consists of four general questions, three essential concepts of the robotics and three concepts of real estate and facility management.

The satisfaction results of 17 students from 14 to 18 years old are summarized as follows. Firstly, the satisfaction score of camp information notification are 66.7% of response from the departments' Facebook pages, 16.7% from the CAMPHUB website, and 16.7% from the school guidance counsellor. Only 16.7% of students said that the knowledge of robotics engineering is difficult. All students thought the video presentation of real estate and facility management is reasonable and 83.3% of students are acceptable for robotics video presentation. Finally, the conceptual components of satisfaction score are as: the level of expectation is of 4.5, correspondence of the camp activities to content is of 4.7, appropriate time is of 4.7, Q&A is of 4.7, provided document is of 4.7, and channels of communication and networks is of 4.7. The average satisfaction score of conceptual is 4.67 of 5.

V. Conclusion

This paper introduces the outcome-based learning in STEM online activities for R^2 Camp. The goal of the R^2 Camp is to offer the knowledge of robotics engineering and real estate & facility management and give an example of robotic applications in real estate and facilities management. Soft-skills and outcome-based methods are proposed on robotics for real estate services as well as in real estate and facility management. We focused on both robotics and real estate and facilities management abilities during the events. The camp was attended by 17 students. The results demonstrate that following the post-test, students' knowledge increased by 10.4%. It is noticed that 50% and 27% of R^2 Camp students have been enrolled in the department of robotics engineering and real estate & facility management, respectively. Finally, it may be concluded that R^2 Camp can inspire and motivate young people to interest in the robotics engineering and real estate & facility management.

Acknowledgment

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A Comparative Study of PCBA Defect Analytical Ability of Male and Female Quality Control Employees by Using Training and GR&R

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Abstract

This study aimed to investigate and compare PCBA defect analytical ability between male and female quality control employees by using training and GR&R. Data were collected from a sample group of 20 quality control employees including 10 males and 10 females. GR&R testing was an instrument given to the sample group of the employees as they were required to explain particular concrete and abstract objects. Analysis of PCBA defects was divided into 2 aspects: 1) decisions making ability from using GR&R, and 2) ability to explain and provide information about waste. The findings indicate that ability of the defect analysis on PCBA, it was found that sex had impacts on PCBA defect analytical ability described as follows. 1) Analysis of decisions making ability from using GR&R indicated that the males had faster ability in analyzing PCBA defects than the females with the average of 3.83% 2) Analysis of ability to explain and provide

information about waste showed that the females were able to give and explain waste information more accurately than the males with the average of 5%. Also, analysis showed that training had effects on both aspects.

Keywords– Gage Repeatability and Reproducibility (GR&R), print circuit board assembly (PCBA), The Decision Making

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A Comparative Study of PCBA Defect Analytical Ability of Male and Female Quality Control Employees by Using Training and GR&R

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***Abstract*— This study aimed to investigate and compare PCBA defect analytical ability between male and female quality control employees by using training and GR&R. Data were collected from a sample group of 20 quality control employees including 10 males and 10 females. GR&R testing was an instrument given to the sample group of the employees as they were required to explain particular concrete and abstract objects. Analysis of PCBA defects was divided into 2 aspects: 1) decisions making ability from using GR&R, and 2) ability to explain and provide information about waste.**

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Keywords*— *Gage Repeatability and Reproducibility (GR&R), print circuit board assembly (PCBA), The Decision Making.

I. INTRODUCTION

The electronic manufacturing industry of PCBA and other industries that manufacture products for international commerce totally face issues arisen during manufacturing or from the manufacturing process. In fact, engineers have designed the manufacturing process and utilized several measurements, such as Statistical Process Control (SPC) and Statistical Quality Control (SQC) that helps with analysis and assessment of the manufacturing process stability to decrease problems in the manufacturing process as much as possible. However, sometimes waste is able to slip out into customer establishment process which affects customer satisfaction. In case the problem is so severe that the manufacturing process is terminated, it will have more negative impacts on organizational image and high production cost.

All establishments make use of manufacturing factors such as human, machine and equipment, method, raw materials, and environment. These factors are used for increasing products as all factors need to be coordinated. The problem is none of the factors is in good condition all the time , and it causes operational problems including loss and waste. Therefore, it is compared study of PCBA defect analysis ability of male and female such issues to ensure up-skill operation. Different sexes had a statistically significant effect on fear traits at the 0.05 level. This hypothesis may be that males and females have different emotional perceptions. Moreover, in behavior, males respond to stimuli faster than females. This is based on research[7]

The objective of this research is to compare PCBA defect analytical ability between male and female quality control employees by using training and GR&R. They have to judgment and explaining information about waste. Gage repeatability and reproducibility are an effective measurement used for analysis and assessment of possible defects in the manufacturing process and impacts of such defects. The measurement also helps in development and improvement by eliminating and decreasing chances of defects to reduce risks of impacts in terms of products versus new manufacturing process, products versus modified manufacturing process, and products versus quality assurance-elevated manufacturing process to maintain customer's highest satisfaction[6].

II. PROBLEM DEFINITION

A. Criteria Visual inspection

The defect ratio is 1.49% of total production, and the damage value are 95,700 dollars. The customer ordered to stop the production line for 2 months, so the industry has to pay cost 12.8 million dollars to the customer.

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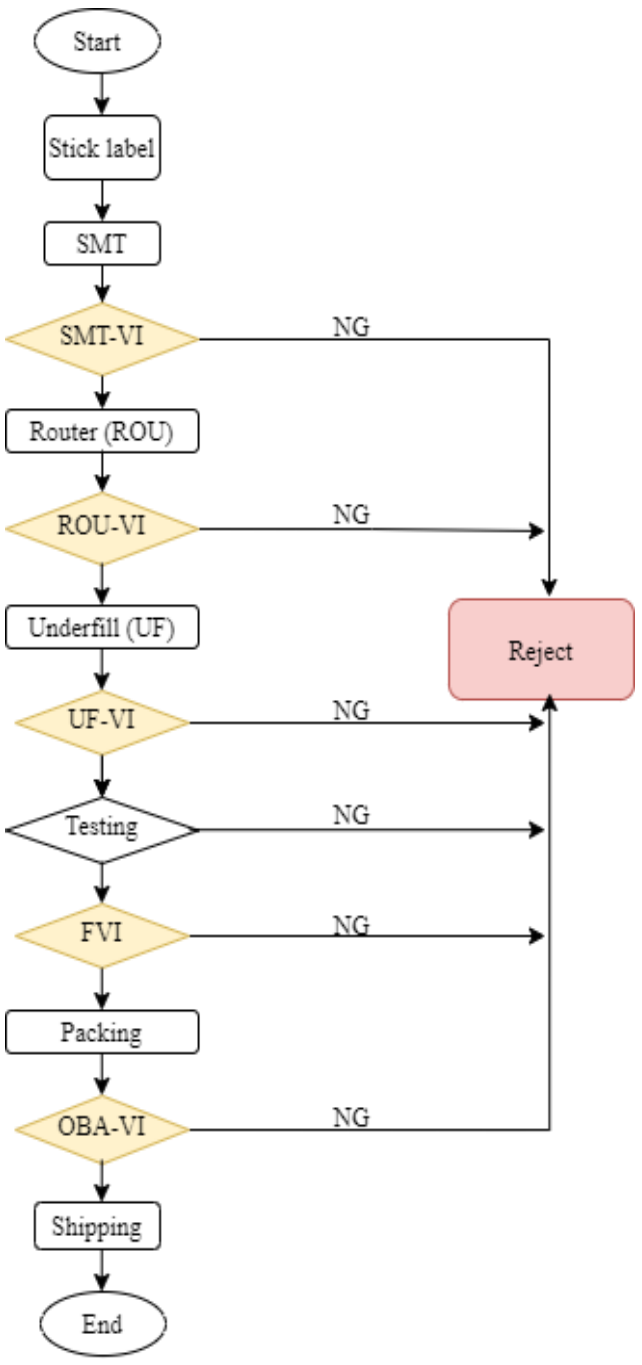

Fig.1 The production process flow of SMT&FATP

- The data in the production process of the industry that made the case study from September 2020 to September 2021, PCBA production usually averages 450k pcs per month. The PCBA have reject 6.7k pcs.
- The quality control operators need to judgement based on SSD standard criteria at the Visual inspection (VI) station. Fig.1 explain the production process flow of SMT&FATP. The Visual Inspection (VI) is most basic method of inspection.

B. Description and formulation of Problem

The goal of the study was to compare PCBA defect analytical ability between male and female quality control employees in the SMT&FATP production. Training and GR&R test was used for data analysis. decisions making ability and explanation of the defect in the factory will increase the efficiency of waste detection for quality control personnel. The production staff quality control department in factory of this research is that the quality control staff are effective in detecting the waste.Fig.2 is fish bone diagram for the defect escape to customer and poor quality[1-3].

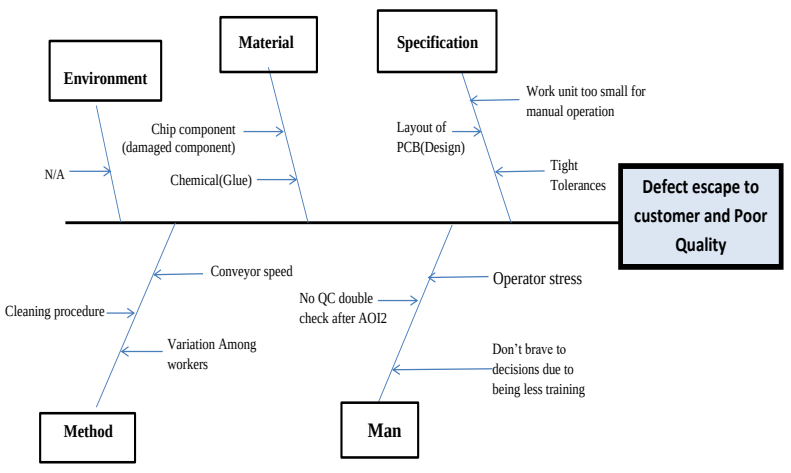

Fig. 2. Fishbone diagram for the defect escape to customer and poor quality

III. INCREASING THE DEFECT ANALYSIS SKILLS

A. Define of skill

The defect analysis of ability for quality control in the production was identified as following:

- The ability to make decisions by GR&R testing
- The ability to explain the defect information

B. The measurement analysis by GR&R testing

We developed a methodology for increasing the defect analysis skills for quality control in the SMT&FATP production line using GR&R training and testing. A sample was selected from the production operator quality control department in factory cases were 20 persons as a sample.

- Specify the criteria of evaluation based on GR&R method.
- Random PCBA samples from production 30 pcs.
- Selected trainee who usually performs the inspection activity regularly.
- Performed the 30 random PCBA sample inspections by each trainee 3 times after training.

IV. IMPLEMENTATION

The proposed was implemented at Cal-Comp Electronics (Thailand) Co., Ltd. For quality control employee development, the visual inspection process was employed as a case study. This training program drew in 20 quality control employees. The training schedule was specific, they would train every day and hold three meetings after each lesson's training was completed. All trainees were required to do a before and after training test and the result of the test was

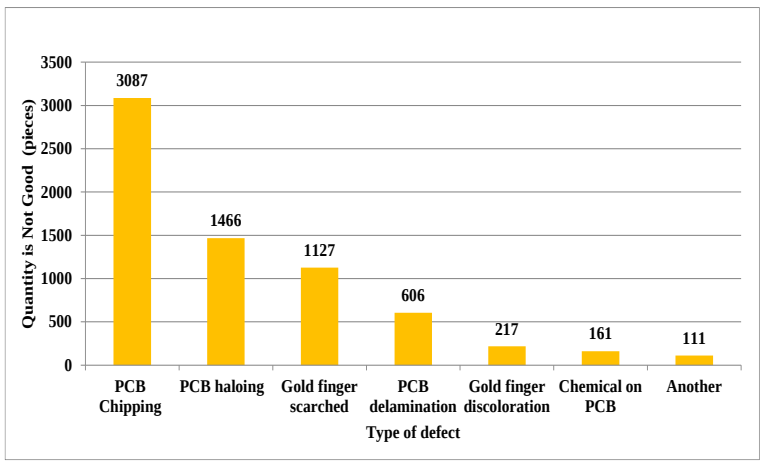

Fig.3 The most appear print circuit board defect in September 2020

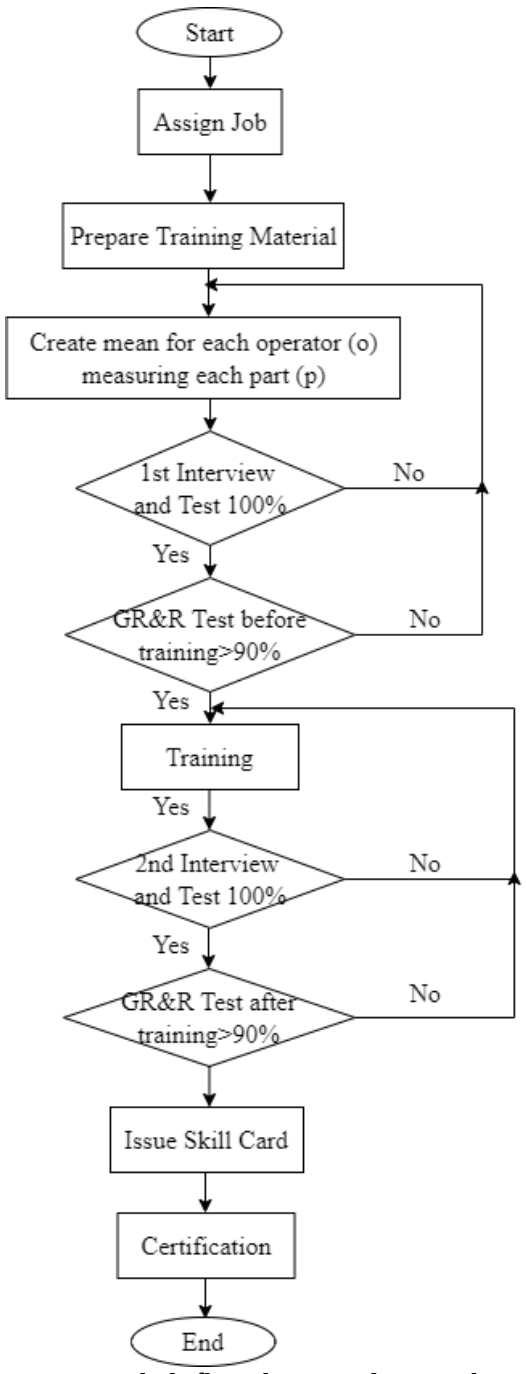

Fig.4 Detailed flowchart explaining how to obtain simulated data to a GR&R study

evaluated with GR&R testing.

V. METHODOLOGY

The study is compare a methodology for analysis the defect of male and female. The solution can be improve the skill of the quality of the products [4] The steps in the decision making and problem-solving have 5 steps as below:

A. Identifying and defining the problem

This is a stage of information gathering, information processing, and deliberation. It often begins with the appearance of problem symptoms, which signal the presence of a performance deficiency or opportunity. Fig.3 is the most appear print circuit board defect in September 2020

B. Generating and evaluating possible solutions

The lists of problems are as follows in a quality failure industry. Fig 2 is fishbone diagram for the defect escape to customer and poor quality.

C. Choosing a preferred solution

The various steps are followed to develop for Cause-and-Effect Diagram. Fig.4 is shows the detailed flowchart explaining how to obtain simulated data for a GR&R study

D. Implementing the Solution

The method is implemented and analyzed the problem. The method was implemented is GR&R and the problem analyzed with interview.

E. Evaluating the results

The decision making process have to an evaluation GR&R and compare the ability to PCBA defect analysis of male and female

VI. RESULT

This research aims to study and compare the ability of the defect analysis of PCBA for quality control between males and females by collecting data from a sample group of 10 male and 10 female. A simulated data will be generated for measurement systems that are unacceptable (%R&R>30%), marginal (10%<%R&R<30%), and acceptable (%R&R<10).

TABLE I. RESULTS FOR ANALYSIS OF DECISION BETWEEN MALE AND FEMALE , %R&R OF APPRAISET BEFORE TRAINING

Gender	S	%R&R	
		1st %R&R	2nd %R&R
Female	**S1**	77.77	77.54
	S2	80.71	82.78
	S3	74.56	75.18
	S4	78.05	78.05
	S5	74.44	73.27
	S6	89.81	**92.14**
	S7	73.32	72.34
	S8	79.31	79.23
	S9	76.98	**90.30**
	S10	**90.58**	**92.38**
Male	**S11**	78.29	**90.02**
	S12	89.10	**90.15**
	S13	80.42	**90.10**
	S14	72.74	73.63
	S15	76.01	76.86
	S16	76.52	77.14
	S17	**92.14**	**92.84**
	S18	**92.13**	**92.99**
	S19	88.41	**90.17**
	S20	**91.34**	**91.34**

Table I, For 1st %R&R,it was found that female employees were able to identify PCBA defects as 1 person acceptable, and male employees were able to identify PCBA defects as 3 persons acceptable. For 2nd %R&R, it was found that female employees were able to identify PCBA defects as 3 persons acceptable,

and male employees were able to identify PCBA defects as 7 persons acceptable.

TABLE II. RESULTS FOR INTERVIEW BETWEEN MALE AND FEMALE OF EXPLANATION BEFORE-AFTER TRAINING

Training	Interview and test operator with questions	Gender	
		Male	Female
Before Training	All inspectors will be interviewed to see if they can find it(1st GR&R).	30%	10%
After Training	All inspectors will be interviewed to see if they can find it(2nd GR&R).	70%	30%

Table II, The result shown before training it was found that female employees were able to analysis of ability to explain and provide information about waste showed that the females were able to clarify and explain waste information 10%, and male employees were able to identify PCBA defects as 30% acceptable.

The result shown after training it was found that female employees were able to analysis of ability to explain and provide information about waste showed that the females were able to clarify and explain waste information 10%, and male employees were able to identify PCBA defects as 30%. The GR&R requires quick decision-making and analytical skills. This will have a positive effect on the cycle time of PCBA production in the production line.

VII. CONCLUSIONS

This paper compares the ability of the defect analysis of PCBA for quality control between males and females by collecting data from a sample group of 10 male and 10 female. Therefore, we should collect the data of the GR&R results in order to apply it to the skill enhancement of those with low GR&R scores. The waste doesn't escape to customers and satisfy customers. Gage Repeatability and Reproducibility (GR&R) as follow:

- The analysis of decisions making ability from using GR&R indicated that the males had faster ability in analyzing PCBA defects than the females with the average of 3.83%
- The analysis of ability to explain and provide information about waste showed that the females were able to give and explain waste information more accurately than the males with the average of 5%. Also, analysis showed that training had effects on both aspects.
- For suggest, In each gender, there is a change in physical, mental, emotional and social and intellectual different. According to age, if the growth and development is appropriate according to age, a person can develop from one skill to another skill as well. We have to improve your fault analysis skills, so in the next research GR&R tolerance should be adjusted from 90% to 95%..

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The author would like to thank the management and all employees of Cal-Comp electronics (Thailand) Co., Ltd. For providing knowledge, assistance, including a place to conduct research.

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Reservoir release forecasting by artificial neural network at Pa Sak Jolasid Dam

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Abstract

Due to floods in the past year The Pa Sak River Basin is therefore another watershed source that causes widespread damage to life and property. An interesting predictive study of the dam release is therefore an experimental idea. Using data recorded at the beginning of '64 using artificial neural networks techniques, compared with a support vector regression model. Estimated for satisfactory results by an ANN precision model R^2 approximately 0.88513 RMSE approximately 8.044 and the SVR model R^2 result. Approx. 0.43369 RMSE Approx. 18.484.

Keywords– Reservoir discharges; Pa Sak River; Pa Sak Jolasid Dam; Discharges forecasting; Artificial neural network

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Reservoir release forecasting by artificial neural network at Pa Sak Jolasid Dam

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***Abstract*— Due to floods in the past year The Pa Sak River Basin is therefore another watershed source that causes widespread damage to life and property. An interesting predictive study of the dam release is therefore an experimental idea. Using data recorded at the beginning of '64 using artificial neural networks techniques, compared with a support vector regression model. Estimated for satisfactory results by an ANN precision model R^2 approximately 0.88513 RMSE approximately 8.044 and the SVR model R^2 result. Approx. 0.43369 RMSE Approx. 18.484.**

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I. INTRODUCTION

At present, it is a wild water flowing from the mountains in Phetchabun, Loburi and Chaiyaphum provinces from the influence of Typhoon Dien Mu to the Pa Sak river. As a result, the amount of water in the Pa Sak dam increased rapidly. Within a week, water volumes increased from 44% of the basin's capacity on Sept. 22 to nearly 107% of the total water volume. Basin capacity today (1 Oct., 2021) statistics from the Royal Irrigation Department also indicate that the amount of water in the Pa Sak Reservoir as of October 1 this year was up to 1,027 million cubic meters. The highest compared to the same days of 2018, 2019 and 2020, which were measured, the water volume in the reservoir was 680 million, 439 million and 375.8 million cubic meters, respectively. The dam is 4,860-meter (15,940 ft) wide and 36.5-meter (120 ft) high dam is earth-filled with an impervious core. Fig.1 the storage capacity is 785 million m^3 of water at normal water level, with a maximum capacity of 960 million m^3. The dam also supplies about 6.7 MW of hydro-electric power.

The main purpose of the downstream drainage is to allow the Pa Sak Reservoir to support the amount of water above which continues to flow in continuously. and to maintain the stability, safety, and security of the dam National Water Resources Office as deputy director of the National Water administration said that at present there are still about 400 million cubic meters that will flow into the Pa Sak Reservoir.

More but because between 28 Sept.,2021 - 2 Oct.,2021 the monsoon trenches will move down across the lower central and southern regions. As a result, there was heavy rain in some areas. Therefore, there may be water flowing into the basin continuously.

The Royal Irrigation Department explains that the amount and speed of water from the reservoir into the Pa Sak River will be set at a level that does not cause too much impact on the downstream area or is at a level that “The Pa Sak river downstream can support water. Without overflowing the embankment of the Pa Sak river" from the Pa Sak Dam in Phatthana Nikhom District, Lopburi province, the water mass drained from the dam will flow into the Pa Sak river through Wang Muang District, Kaeng Khoi District, Mueang Saraburi District, Saraburi District. Sao Hai of Saraburi province, then it will reach Rama 6 Dam in Tha Ruea District, Phra Nakhon Si Ayutthaya province.

The water management of the Pa Sak Dam in emergency and urgent situations in order to minimize the impact on all parties must be done in this kind of situation. This study used data on water inflow rates. the water level in the basin Reservoir storage volume and rainfall. Such data were collected from January 1, 2021, to November 2, 2021, by the Reservoir Water Database System, the Royal Irrigation Department to help analyze the probability of water release using Artificial intelligence technology studies behavior and train models to learn from the recorded. To accurately predict tides play an important role in the effective management of water resources during droughts and floods. water storage and reservoir operations traditional methods have been studied and models for predicting tides and rainfall can be divided into two categories: physical methods and empirical methods [1][2]. physical form forecasts are generated by models built from system equations to predict tides or rainfall. Related weather forecasting systems such as temperature changes precipitation forecast and changes in water pressure are used as mathematical equation variables to create forecasting models. The application of these models depends on the region studied and the data available for that region. Physical modeling for better illustration.

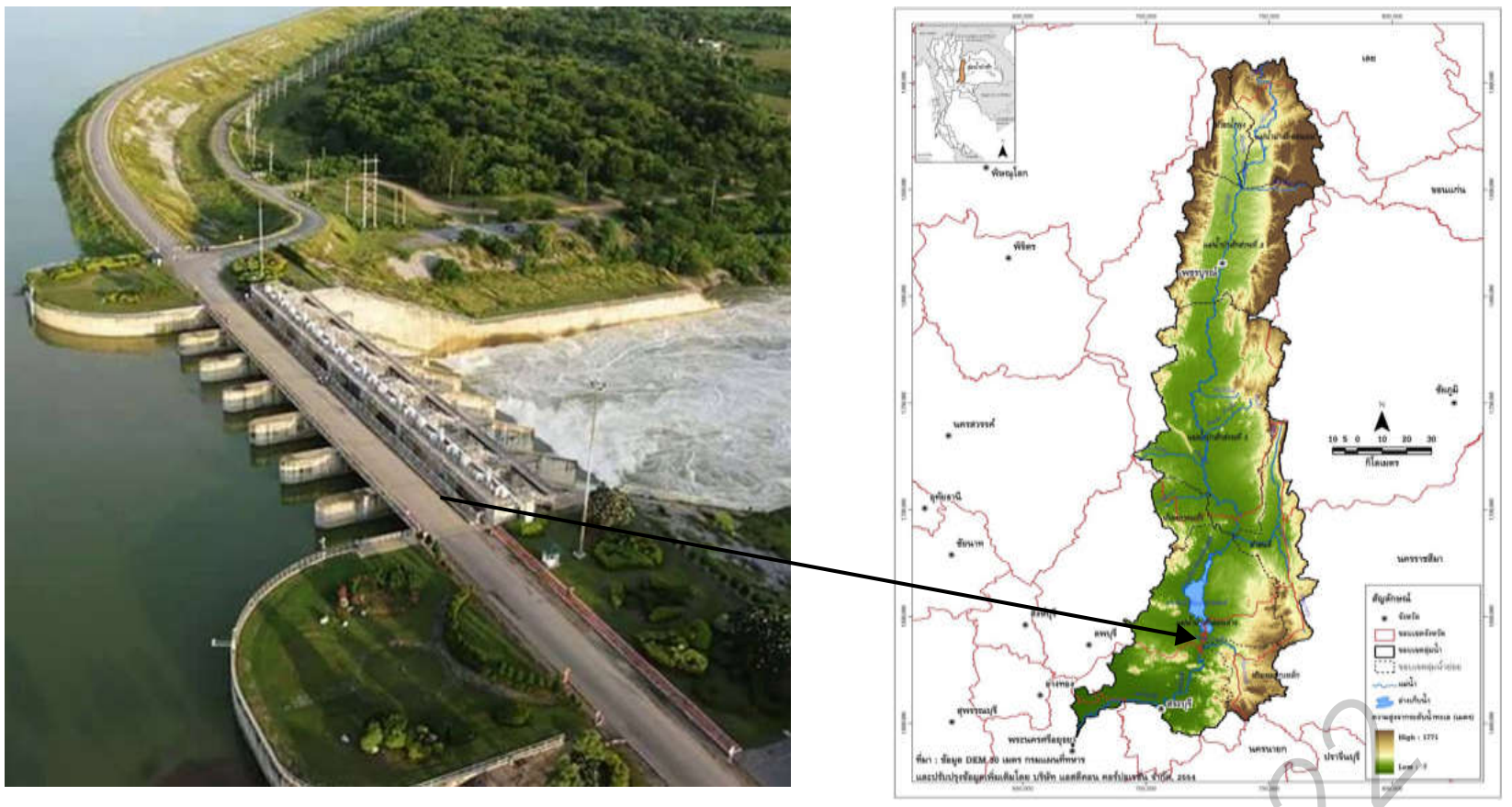

Fig.1 Pa Sak Jolasid Dam and watershed area 15,625.87 Km^2

It provides comprehensive and straightforward information about the processes involved in predicting tides. These models are used as parameters that are directly linked to watersheds. However, the predictability of physical models requires comprehensive data. which sometimes may be difficult to find in the study area [3]. The empirical approach is based on an analysis of historical aquatic climate data and its relationship to a much wider range of areas. Empirical techniques involve statistical models or classical machine learning models such as linear regression. Support vector machine fuzzy logic Nearest neighbor average, etc. [4]

Machine learning models, part of the widely used artificial intelligence technology, were used in this study. and then used to calculate the accuracy of the model. to use as a hypothesis and reference in further in-depth study this study used the dataset in the Fig.2 as a relationship. before making a forecast data are inserted into the model multilayer perceptron neural network according to table1, a dataset the feature to rain, storage, w inflow and set the target to release, let the model train, test the data from a feature, target. In this study, train 70%. and test 30% of the items recorded at the beginning of 2021 of 294 rows × 4 columns.

The remainder of this document follows where we describe the relevant work in Part 2. while our dataset is covered in Part 3. The models used in this work are reported in Part 4. The results are discussed in Part 5 and conclusions in Part 6.

II. Related work

In the study of machine learning algorithms and especially neural networks. (ANN) for use in applied hydrology It has been studied for a long time such as Dahamsheh and team [5] have successfully implemented rainfall forecasting. Callegari's team[8] predicted river flows using the Support Vector Regression (SVR) technique in 14 reservoirs as monthly data in northern Italy. Effective results are obtained compared to long-term and linear models. They show that the SVR model has RMSE (Root Mean Square Error) = 22% on a 1-month forecast. [9, 10], Centuries of meteorological hydrological analysis for the Adda Basin (Central Alps). The basis of the nervous system ANNs are composed of multiple layers of neurons. It consists of an input layer, a hidden layer which can contain more than one layer, and an output layer. For creating high-performance models to predict outcomes in supervised regression, the input data is directed into the system for training, validation, and testing procedures. Used to calculate and upgrade network elements such as weights and bias. Validation procedures or evaluation of the effectiveness of the training process. After that, it will be the final test of the system.

	Feature			Target
Date_stamp	rain	storage	inflow	release
0	0	653.7	0	3.03
1	0	639.9	0	1.3
2	0	637.1	0	2.17
3	0	634.3	0	2.17
4	0	631.6	0	3.47
...	...	...	...	...
289	290.5	980	35.84	34.59
290	226.5	982	34.64	30.31
291	1	989.8	38.52	30.31
292	1	998	38.53	30.32
293	64	1011	43.43	30.3

Table 1 Data frame for prediction model

Feed Forward neural networks

The forward arrangement and connection produce static ANNs, the simplest type of neural network structure. The input signal travels to the input layer with weights and bias, passes through the hidden layer, and also contains weights and bias in it. before being passed to the output layer. Without any loops, Feed Forward Neural Networks (FFNN) is a well-known construct. It is practical and has the simplest structure as in Equation (1). A two-layer feedforward neural network with n input units, m output units and N units in the hidden layer, is shown in Fig. 2

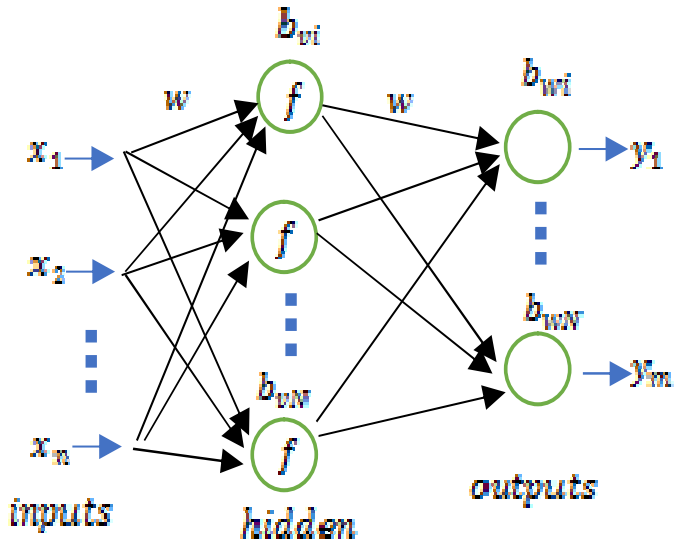

Fig.2 Feedforword Neural Network

The output vector y is determined in terms of the input vector x by the formula

$$y_i = \sum_{j=1}^{N} [w_{ij} \cdot f\left(\sum_{k=1}^{n} v_{jk} x_k + b_{vj}\right) + b_{wi}] ; i = 1, \ldots, m \quad (1)$$

where f are the activation functions of the neurons of the hidden layer. The inputs to hidden layer intercom-nection weights are denoted by v_{jk} and the hidden layer to outputs interconnection weights by w_{ij}. The bias weights are denoted by b_{vj}.

Support Vector Regression

Support Vector Regression (SVR) is a variant of the support vector machine (SVM) algorithm that distinguishes data belonging to different classes. using hyperplane line This hyperplane is the ultimate line between data classes. If the data cannot be linearly split, the SVM uses a non-linear function called kernels, to automatically translate instances of the training data, Support Vector Regression (SVR) into a type of SVM applied to real numbers. In the case of regression The margin of tolerance or maximum error is set to suit the desired accuracy. The idea is to minimize errors. by the hyperplane, which must calculate the margin bearing in mind that some errors are acceptable. Michelle Pini and colleagues [11] conducted an experiment. Reservoir forecast in Italy SVR is one of the experiments. Compare to Other models The experiment yielded quite accurate results.

III. DATA SET PREPARATION

From the foregoing above The data from this experiment, recorded from National Water Resources Office in January 1, 2021, to November 2, 2021, are shown in Table one to three column are Features and one Target with 294 rows.
Interesting features are

- Rain fall
- Storage of dam
- inflow to dam

The water release data during that time period is used to forecast the model. when bringing Feature In which we are interested in the mapport graph compared to the recording time period, the time-of-year relationship to water management is shown in Figures 3. show water management in the conditions noted above as a relationship. of the amount of water inflow into the dam, the amount of water retention, and the depletion of the dam under normal and high-water situations.

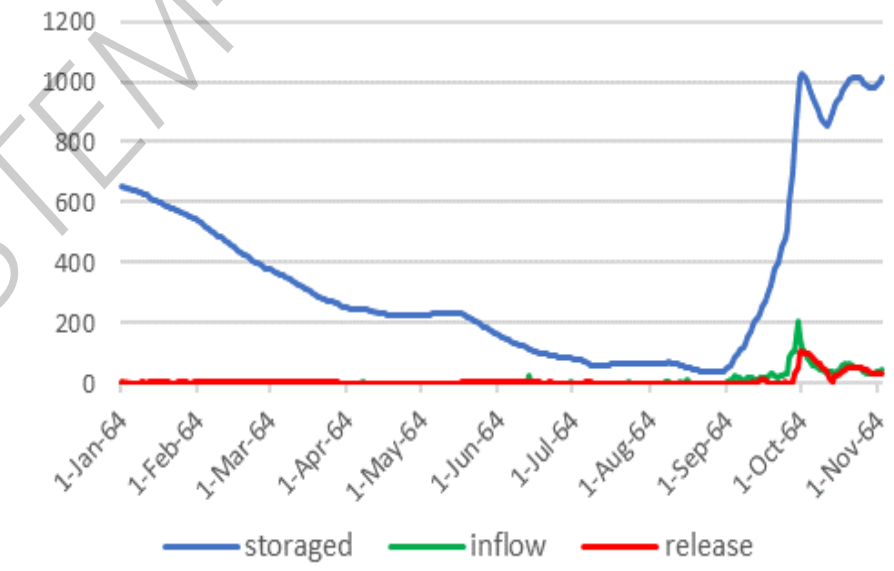

Fig. 3 Actually water management

Figures 4. Show rainfall throughout the period of measurement, it can be seen that there is a lot of rain during the storm in late October. and related to the amount of water flowing into the Pa Sak Dam.

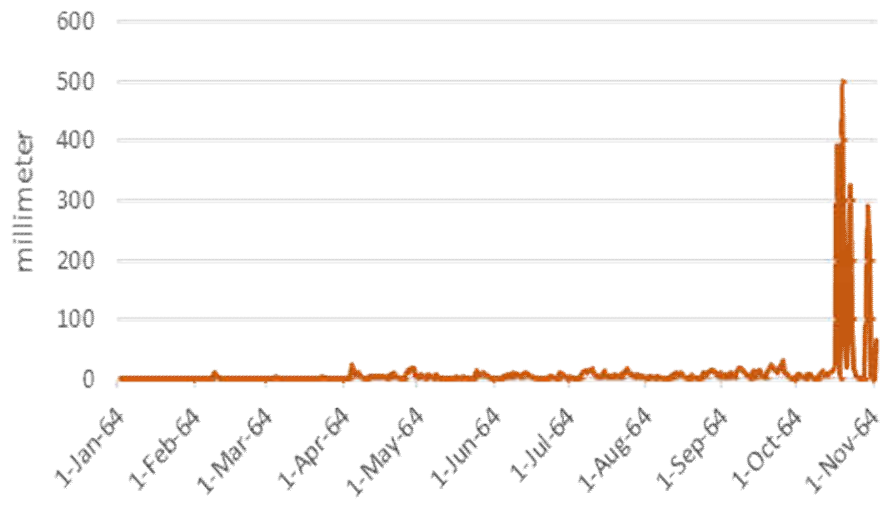

Fig. 4 Amount of rainfall

In the experimental process, Feature and Target data were examined for accuracy, Clean missing data and making the training/test split with approximately a 70/30 ratio. these models is assessed using two metrics namely the root mean squared error *(RMSE)* and the coefficient of determination *(R^2)* estimated as:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2} \quad (2)$$

$$R^2 = 1 - (\sum_{i=1}^{n}(\hat{y}_i - y_i)^2)/(\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2) \quad (3)$$

IV. MODEL USED.

An experiment using the principles of ANN and SVR will be done in the form shown in Figure 5. is to take the collected data, select columns of data set, clean missing data, then extract the data to get the data to train 2 parts of 70 percent, the other 30 percent will be tested. Both Feature and Target, when the model are processed, takes this information for accuracy and discrepancy. This will show the difference when comparing ANN and SVR.

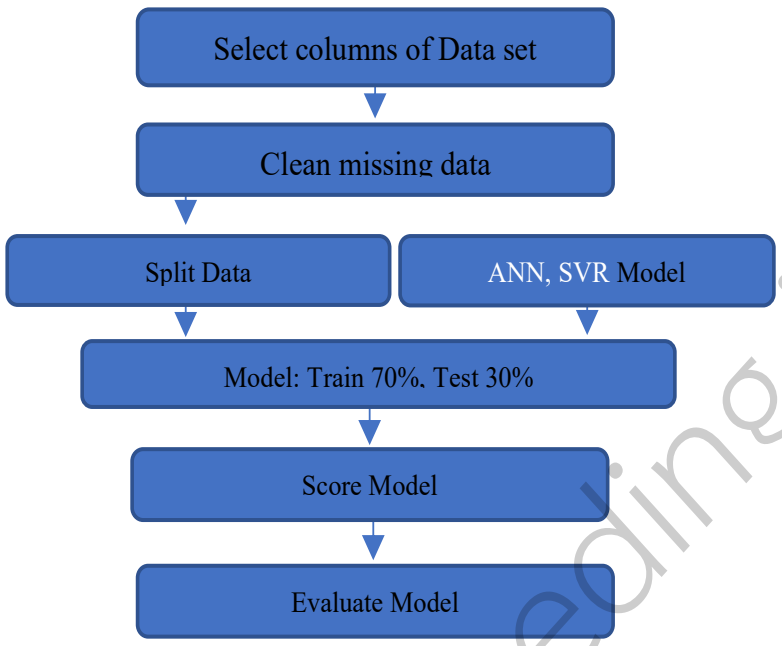

Fig. 5 Overview of research methodology of the study

V. RESULTS AND DISCUSSION.

The result of predicted and actual for ANN model is shown in Fig. 6 scatter plots on test set in x-axis actual values, in y-axis predicted values. In blue line of perfect agreement. The blue dot shows the expected number of samples/instances predicted and aims to find predictions near the diagonal blue line. However, an analysis of the results by ANN found that the projections were closer to the diagonal blue line than the SVR model in Fig. 7 and, considering the ANN's R2 accuracy, it was 0.88513. and a tolerance of RMSE 8.044, while the SVR model gave R2 0.43369 and RMSE 18.484.

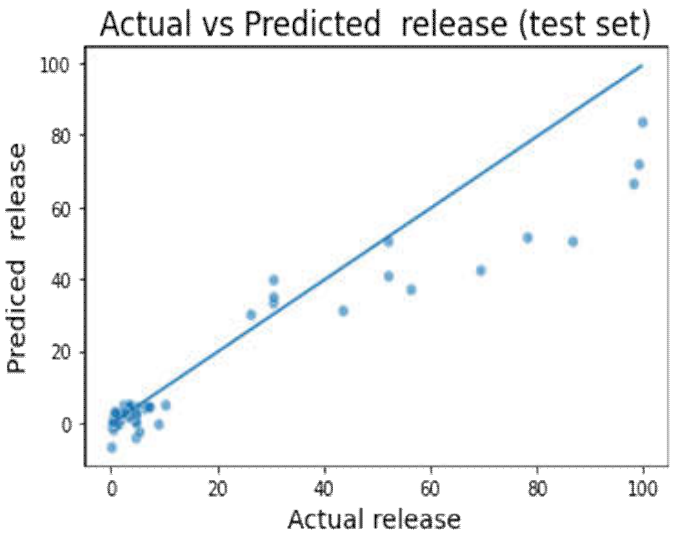

Fig. 6 the result of predicted and actual ANN model

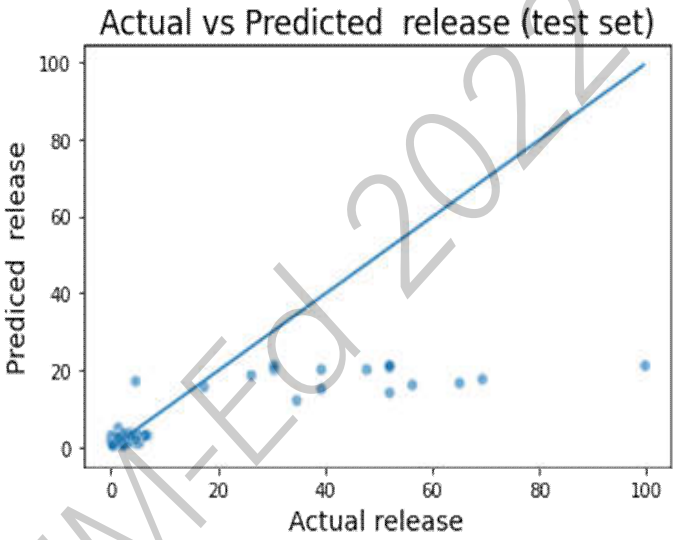

Fig. 7 the result of predicted and actual SVR model

VI. CONCLUSION.

Reliable estimation of hydrological parameters is essential for managing and preventing natural hazards. Tides forecasting plays an important role in regulating the amount of water. Data-driven models provide insights that help make good decisions. Hydrological data show a nonlinear data model. in this study Various machine learning models were examined. for effective forecasting of currents in dams We looked at different statistical measures to assess the model's performance. We found that ANN showed outstanding results compared to SVR. This is due to ANN's ability to learn nonlinear data models. In the future, we will consider other meteorological variables such as (farmers' water needs, La Niña and El Niño phenomena, wind speed and solar radiation), which are important variables affecting all currents. in Pa Sak Jolasid Dam

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P02371

Developing Training Set for Competency Enhancement in Basic Electrical and Electronics Works for Unskilled Learners

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Abstract

This article aims to developing a training set for competency enhancement in basic electrical and electronic works specifically for unskilled first-year students of the Faculty of Industrial Technology, Chitralada Technology Institute, and evaluating the effectiveness of the developed training set. First, the backward design approach was applied to consider learning goals to formulate a curriculum through five activities including searching and determining, 2) experimenting, 3) discussing and exchanging, 4)concluding and evaluating, and 5) applying.Then, students' learning outcome and competency was evaluated by observation form, tests, and competency evaluation. The results revealed that 1) the competency evaluated by experts was effective, and 2) the quality of the training set was high. Therefore, the developed training set can be effectively applied to enhance unskilled students' competency in basic electrical and electronic works.

Keywords—Training set for competency enhancement in basic electrical and electronic works, Unskilled learners

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Developing Training Set for Competency Enhancement in Basic Electrical and Electronics Works for Unskilled Learners

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Abstract— This article aims to developing a training set for competency enhancement in basic electrical and electronic works specifically for unskilled first-year students of the Faculty of Industrial Technology, Chitralada Technology Institute, and evaluating the effectiveness of the developed training set. First, the backward design approach was applied to consider learning goals to formulate a curriculum through five activities including searching and determining, 2) experimenting, 3) discussing and exchanging, 4) concluding and evaluating, and 5) applying. Then, students' learning outcome and competency was evaluated by observation form, tests, and competency evaluation. The results revealed that 1) the competency evaluated by experts was effective, and 2) the quality of the training set was high. Therefore, the developed training set can be effectively applied to enhance unskilled students' competency in basic electrical and electronic works.

Keywords— training set for competency enhancement in basic electrical and electronic works, unskilled learners

I. INTRODUCTION

Industry 4.0 requires the implementation of technology, especially the artificial intelligence or AI to boost the country's productivity in terms of potential and supply chain [1]. The illustrative examples of the technology in Industry 4.0 includes Big Data and Advanced Analytics, Autonomous Robots, Simulation, Industrial Internet of Things, or Additive Manufacturing which have transformed the production process building up integrated network that learns, exchanges data and display results, resulting in the increase of efficiency and productivity while reducing waste, cost, and pollution [2]. This will also boost the country's competitiveness [3]. Thailand puts focus on value-based economy by creating Eastern Economic Corridor of Innovation highlighting six target industries following s-curve industries including innovative agriculture, biorefinery, highly efficient battery and modern logistics, robotics and automation, aviation technology and unmanned aerial vehicle, and medial equipment [4]. However, Thailand's industry sector in the post-Covid-19 world still encounters obstacles and challenge concerning productivity, technology implementation, and workforce shortage [5].

Accordingly, all sectors are aware of the importance of skilled workforce in the improvement of the productivity and the economic growth [6]. When the COVID-19 pandemic began, the so-called "job polarization', distinguishing "low-skilled" and "high-skilled" jobs, became clearer [7]. The requirement of high skilled workforce increases due to the fact that the technology is used for complex tasks replacing unskilled or low-skilled workforce. Still, the preparation of skilled workforce takes time. It is estimated that five years in educational system are needed to prepare a graduate with required skills. New graduates do not work in the samed field of their education [8], and they can lose their skills. Therefore, self-development of skills is an alternative to increase income and quality of life. Skills concerning STEM (Science, Technology, Engineering, Mathematics) are becoming even more necessary [9] since they involve in how learners develop innovation, communicate, share knowledge, collaborate, and apply creative thinking [10].

To develop high-skilled workforce and enhance their competency in accordance with the industry's needs, the workforce is required to develop potential and ability. The application of skills for career is called "competency" that can be diverse depending on professional fields [11]. To meet occupational standard, the development of learning activities is also required to enhance skills that are needed for the industry sector. In addition, "competency" can be applied as the starting point to organize learning activities in industrial technology program to appropriately evaluate learners' behavior. Thus, teaching and learning development in accordance with "competency-based occupational standards" can improve learners' knowledge and experience through outcome-based learning focusing on the application of knowledge, skills, attitude, and desired charcteristics [12] to solve problems and link to real-world working life [13]. Self-learning, information literacy as well as

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creative thingking skills are also required to collaborately solve problems and create [14]. The development of professional competency according to learners' needs involve in the promotion of self-directed and life-long learning [15].

Developing a tool to enhance the competency needed by the industry sector requires the analysis of basic competency in electrical and electronics works for unskilled learners. Then, result from the analysis is used to innovate instructional media as a tool to organize learning activities capable of enhancing learners' competency. This article will concern the project that is applied as an instructional media in training set to enhance basic competency in electrical and electronics works for unskilled learners with a view to prepare the graduates for Thailand 4.0.

II. RESEACH OBJECTIVES

A) to develop a training set to enhance basic competency in electrical and electronics works for unskilled learners including the first-year students of the Faculty of Industrial Technology, Chitralada Technology Institute (CDTI);

B) to evaluate the effectiveness of the above-mentioned training set.

III. CONCEPT OF THE TRAINING SET DEVELOPMENT UNDER COMPETENCY-BASED OCCUPATIONAL STANDARD FRAMEWORK

The Faculty of Industrial Technology, Chitralada Technology Institute operates the Bachelor of Technology in Electrical Technology Engineering program following Her Royal Princess Maha Chakri Sirindhorn's initiative of "Study and Work" program with the objective of preparing good, skilled, disciplined, and ethical graduates. Moreover, the focus is also put on graduates' enthusiasm to learn, perseverance, and ability to communicate in Thai and English as well as a third language including Chinese, Japanese, German, and French. The graduates should have the competency that supports the rapid technological change in Thailand 4.0, corresponds to the 21st century skills, and meets international standards. The "Study and Work" program is the result of the collaboration between organizations and CDTI. The students spend three years in the institute and one-year practice in organizations to strengthen their competency and expand their experience before graduating. They will also be immediately employed after graduation by the organization in which they carry out the internship.

Students who would like to pursue the studies in the faculty must possess at a high school diploma or a vocational certificate in any field as required for the enrollment. High school education emphasizes on five competencies including communication, thinking, problem solving, life skills, and technology literacy. In parallel, vocational education stipulates that students at all levels and in all fields of study must be qualified in four aspects including 1) morality, ethics and disired characteristics, 2) knowledge, 3) skills, and 4) ability to apply and responsibility, which correspond to National Qualifications Framework, occupational standards, organizations' and market's needs. Considering these criteria, there is a discrepancy in terms of students' readiness and basic skills, resulting in student's difficulties in undertanding and adaptation that, in turn, would lead to lower-than-expected learning outcomes and, in some cases, expulsion. Therefore, the program has set up preparation sessions of engineering and technical skills to prepare the students for higher education. Another objective is to allow the students to apply engineering and technical skills in classes, use tools and equipment correctly and safely, and finally, enjoy their four-year studies.

The Faculty of Industrial Technology recuites new students from different background of knowledge, resulting in student's difficulties in undertanding that would lead to lower-than-expected learning outcomes and, in some cases, expulsion. Therefore, the Faculty of Industrial Technology has set up a 35-day preparatory training of engineering and technical skills as well as other necessary skills for higher education. This training sessions allow the students to adjust, know how to use tools and equipment correctly and safely, and prepare themselves for more complex courses throughout the program.

Following the observation above, the development of a training set to enhance students' competency in electrical and electronic works applied "Developing a Training" process to perform needs assessment. Learning outcomes are formulated with backward design approach, they are, then, considered as a guideline to determine learning objectives, design evaluation and assessment methods, and plan learning activities.

IV. RESEARCH METHODOLOGY

A) The development of a training set applies Backward is a process to develop a training course by fixing the objectives before designing instructional methods, learning activities, and forms of evaluation, generally consists of four stages.

Stage 1 Identify desired results to consider desired knowledge, as well as students' ability or outcomes. To do so, documents and related research papers are reviewed and analyzed before asking advice from and discussing with the experts and the faculty lecturers who have at least 10 years of experience in curriculum designing.

Stage 2 Determine acceptable evidence of learning to set behaviors or evidence of students' results or learning outcomes. For this research, the training set consists of a teacher manual, a smart plug practice set, and VDO media. And the evidence of students' learning outcomes consists of observation form, tests, and competency evaluation form, as shown in Fig. 1.

Fig. 1 Training set for competency enhancement of unskilled students in basic electrical and electronic works

Stage 3 Plan learning experiences and instruction, the smart plug was designed to operate across 220Vac that can support 2000W load. The detail is presented below.

For the first part, the signal is transmitted from an application that was developed to use with Blynk application in smartphone that control turn-on and turn-off functions of the smart plug, as shown in Fig. 2.

For the second part, the signal is received by the ESP32 microcontroller powered by a switching power supply that transforms 220Vac into 5Vdc. The microcontroller is designed as a relay to control alternating current switch.

Finally for the third part, the smart plug operation status is displayed on an LED screen connected via Wi-Fi signal and can be reset in case of anomaly.

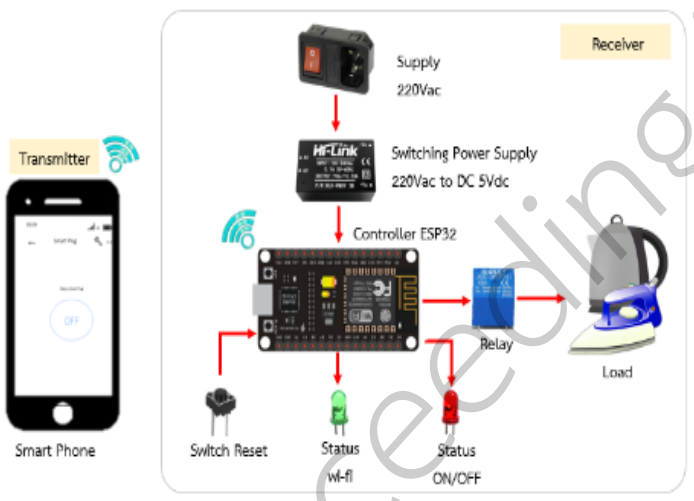

Fig.2 Smart plug used in the developed training set

Stage 4 The development of learning activities follows the framework that [10] had proposed for students in industrial technology program, which consists of five activities including 1) searching and determining, 2) experimenting, 3) discussing and exchanging, 4) concluding and evaluating, and 5) applying.

The details of each activity are as follows.

1) Searching and determining: Students search for data to determine how they can identify problems and attempt to find answers.

2) Experimenting: Students practice, test, or experiment with diverse instructional media and measuring tools. The collected data are then analyzed, the statistics are compared, and conclude.

The students practice the smart plug that is controlled by a smartphone application. The smart plug is designed by the following steps.

1. Design and make the box structure with 3D printer.
2. Make a print circuit board (PCB).
3. Assemble electrical and electronic equipment on the PCB.
4. Develop a control system with Arduino IDE.
5. Develop a smart plug control application with Blynk application.
6. Test the operation for further improvement.

3) Discussing and exchanging: Students present, discuss, and exchange the results and statistic data from the experiment, and suggest problem solution.

4) Concluding and evaluating: Lecturers and students conclude what they have learnt. Students' skills and knowledge are then assessed and evaluated before improving some weak points.

5) Applying: Students apply their knowledge and skills from the practice into the creation of innovation, or during their internship in organizations to improve knowledge, skills, and experience from real professional situation.

Stage 4 Evaluate learning activities: this stage is added to evaluate integrated learning activities through a forum where experts and related faculty lecturers discuss and consider appropriate learning activities for the students.

V. Research Result

The result of the development of a training set for competency enhancement of unskilled learners in basic electrical and electronic works with project-based learning approach is as follows.

4.1 The result of the competency effectiveness evaluation

The competency effectiveness was evaluated by five experts with at least 10-year experience in the industrial technology sector and in the electrical and electronic field, as well as those working in industrial enterprises. They are asked to determine the validity of students' competency evaluation criteria and the effectiveness of scoring rubric criteria in each module. The results were analyzed applying the item-objective congruence or IOC. The result indicates that the validity score of the evaluation criteria is less than 0.5, which means that the criteria are valid and congruent with the objectives of the research. And it can be effectively applied to evaluate students' competency. The details are shown in Table I.

4.2 The result of the training set quality evaluation

The developed learning activities to enhance students' competency consist of five activities including 1) searching and determining, 2) experimenting, 3) discussing and exchanging, 4) concluding and evaluating, and 5) applying. The result from the experts indicate that the developed training set has high quality. The activities can enhance students' competency and engage them in training activities following the project-based learning framework. The details of the result are shown in Table II.

TABLE I THE RESULT OF THE COMPETENCY EFFECTIVENESS EVALUATION

List of competencies	A	B	C	IOC	Interpret
1. Student can use technical and mechanical tools.	5	0	0	1.00	agree
2. Students practice and comply with safety standards and other related standards.	5	0	0	1.00	agree
3. Students can perform technology engineering drawing and design innovation.	5	0	0	1.00	agree
4. Students can apply IT tools and equipment in practice.	5	0	0	1.00	agree
5. Students can install, repair, and maintain basic electrical and electronic equipment.	5	0	0	1.00	agree
6. Students can read and draw electrical and electronic system.	5	0	0	1.00	agree
7. Students can select basic electrical and electronic equipment and system.	5	0	0	1.00	agree
8. Students can use basic microcontroller program.	4	1	0	0.80	agree

*remark: A = congruent, B = questionable, C = incongruent
IOC = Item-Objective Congruence Index

TABLE II THE RESULT OF THE TRAINING SET QUALITY EVALUATION

Item	Mean	S.D.	Result
1. The training set enhance the competency in electrical and electronic works.	4.20	0.45	High
2. The training set can be applied in technology teaching.	4.40	0.55	High
3. The learning activities are appropriate.	4.20	0.84	High
4. Supporting media are enough and appropriate.	4.40	0.55	High
5. The activities can be efficiently in real work.	4.60	0.55	Very High
Average value	**4.36**	**0.41**	**High**

V. SUMMARY

This article has presented the development of a training set to enhance students' competency in basic electrical and electronic works to respond to practical competency needs of organizations and industrial sector. Learning activities are conceived with the learning framework applying to unskilled learners.

The result of the competency effectiveness evaluation from the experts confirms the validity of the competency criteria (0.80-1.00). It is not exaggerating to conclude that these criteria can be applied to evaluate students' competency and enhance students' competency effectively.

The developed learning activities consist of five activities including 1) searching and determining, 2) experimenting, 3) discussing and exchanging, 4) concluding and evaluating, and 5) applying. The result from the evaluation reveals that these activities obtain a score of 4.36 (S.D = 0.41). Therefore, they can effectively be applied to enhance students' competency in basic electrical and electronic works.

In conclusion, the developed training set can reduce the gap of students' basic skills and prepare them to apply what they have learnt during the training into their studies. They can also use tools and equipment correctly and safely. In addition, they know how to adjust themselves for the studies in higher education that requires skills for more complex courses, and finally enjoy their four years in the institute.

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P02324

Computer Simulation-Based Learning: Student Self- Efficacy During COVID-19 Outbreak

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Abstract

Due to the COVID-19 as a pandemic, the government has forced the nationwide shutdown of several activities, including educational activities. It has resulted in gigantic migration of universities with education over the internet serving as the educational platform. Hand-on-based learning becomes a new challenge. This paper aims to investigate the effect of computer simulation-based learning on student self-efficacy in an electric circuit analysis course. For the 17 participants included in this study, the students have overcome their existing achievements indicated by a long-term average score. Computer simulation-based learning provides positive results on student self-efficacy. Students also perceived a valuable learning experience.

Keywords— Computer Simulation-Based Learning, Electric Circuit Analysis, Self-Efficacy Assessment

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Computer Simulation-Based Learning: Student Self-Efficacy During COVID-19 Outbreak

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***Abstract*—Due to the COVID-19 as a pandemic, the government has forced the nationwide shutdown of several activities, including educational activities. It has resulted in gigantic migration of universities with education over the internet serving as the educational platform. Hand-on-based learning becomes a new challenge. This paper aims to investigate the effect of computer simulation-based learning on student self-efficacy in an electric circuit analysis course. For the 17 participants included in this study, the students have overcome their existing achievements indicated by a long-term average score. Computer simulation-based learning provides positive results on student self-efficacy. Students also perceived a valuable learning experience.**

***Keywords*—Computer Simulation-Based Learning, Electric Circuit Analysis, Self-Efficacy Assessment**

I. INTRODUCTION

Sciences, Technology, Engineering, and Mathematics (STEM) contain complex models of real-world systems. STEM students need to have special training to make decisions that affect complex systems with enormous variables and interactions among their components [1]. In addition, real-world systems are usually subject to uncertainty, which is generated by human configuration-based systems [2-4]. These facts cannot be completely included in conventional analytical models, and require the use of computer simulation-based methods in coordination with other techniques, such as nature-inspired optimizations [5-8] and supervised models [9-13]. The use of computer simulation programs, tools, and games encourages the theoretical and practical understanding of these complex systems and allows students to improve their learning capability through the development of hands-on activities appropriately designed by their instructors [14-17].

Computer Simulation-based Learning (CSL) technique delivers the use of simulation(s) for learning purposes [18]. Learning practices by CSL programs, tools, and games are interesting in academic and industrial societies, who consider in CSL the way to develop their students and future employees. Figure 1 illustrates the number of articles in Google Scholar searched by the term "Computer Simulation-Based Learning" from 2000 to 2021. It notes that the number of research articles has been published in 2000 with 32,200 articles to more than 123,000 articles in 2021. Also, regression methods have been applied to forecast for the next few years. Based on the statistical forecast, the number of articles will reach the level of 140,000 articles in 2025, approximately.

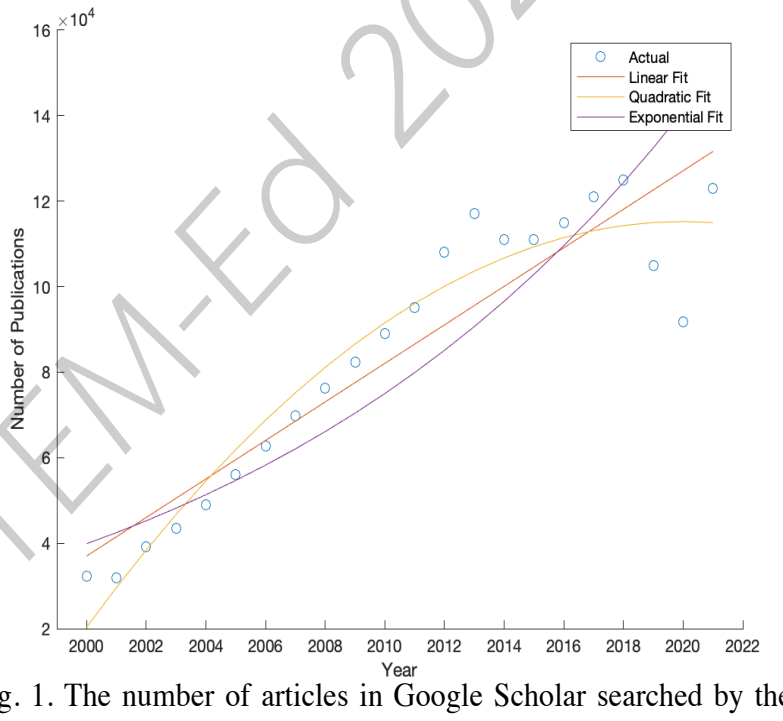

Fig. 1. The number of articles in Google Scholar searched by the term "Computer Simulation-Based Learning"

Engineering education relies on the availability of different laboratories; however, the scenarios universities are exposed to vary depending on the financial subsidization by a government. Individual learning experiences vary in students' educational backgrounds, resulting in possibly missed learning opportunities.

To address the limitation of laboratory-based education, CSL has been proposed as an additional educational strategy. CSL demonstrates to recreate real-world experiments through simulated scenarios, environments, providing a safe environment [19-22]. With CSL, learning experiences can be customized to specific learning and can be set up on-demand, eliminating the lack of laboratory availability.

The existing reports on online engineering courses [23, 24]. The analysis of the challenges affecting the pandemic of online engineering courses in universities shows that students need to improve their self-efficacy.

This paper aims to investigate the effect of CSL on student self-efficacy in the electric circuit analysis

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assessment. The remaining sections of the paper are structured as follows. In section II, the electric circuit simulation with MATLAB® Simulink is presented. Section III exhibits the results and discussion of the proposed CSL. Finally, the paper ends with the conclusion in Section IV.

II. Electric Circuit Simulation with MATLAB® Simulink

This study was a prospective, experimental study using weekly scores to assess student performance with CSL as a learning strategy.

A. Participants

Students studying in the electrical engineering major at Rajamnagala University of Technology Phra Nakhon (RMUTP), Faculty of Industrial Education, enrolled in the Electric Circuit Analysis academic course of study, which was delivered in the 1st year of their electrical engineering program.

B. Outcome Measures

Students' level of self-improvement was demonstrated with CSL, where self-efficacy is an individual assessment of their ability to accomplish tasks. The primary outcome measured in this research project was student self-efficacy in assessing electric circuit analysis. The resulting analysis using CSL helps validate students' calculated responses in electric circuits. In addition, CSL can confirm learners' understanding. Student self-efficacy was measured using weekly self-scores calculated by using 4-week moving average scores.

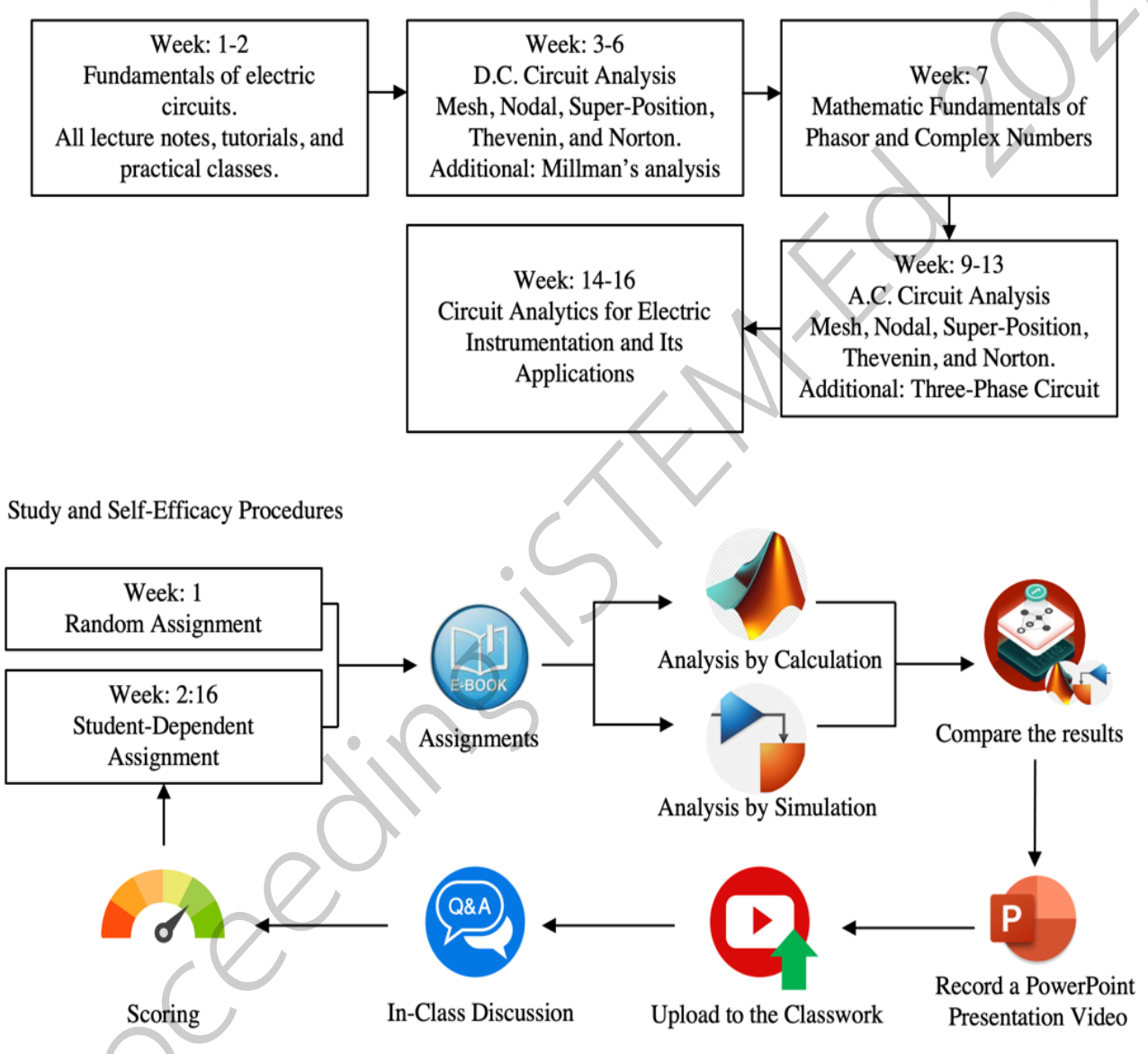
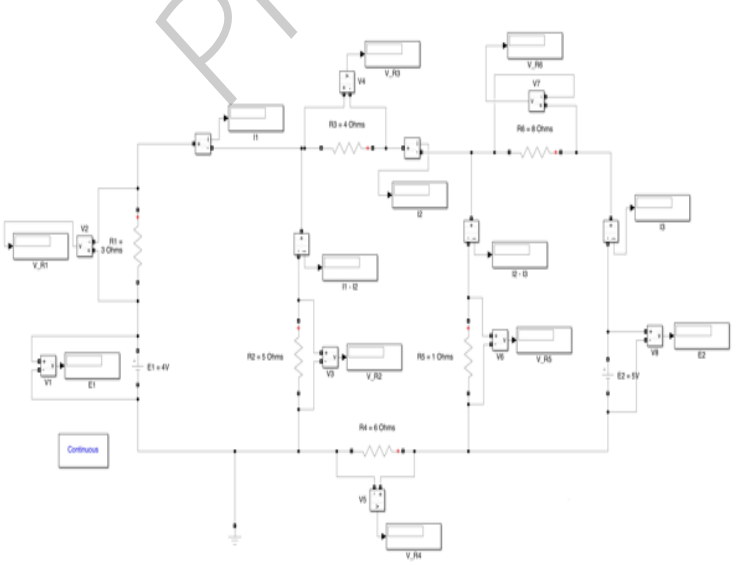


Fig. 2. Timeline of Study Procedure



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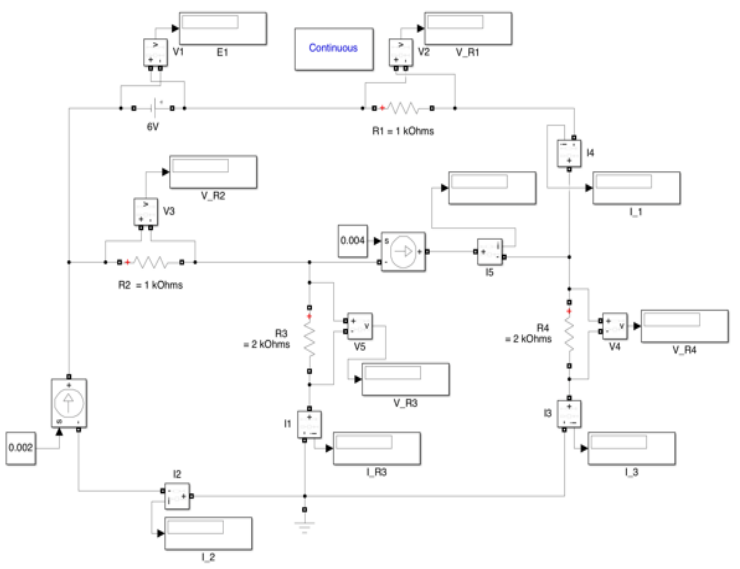

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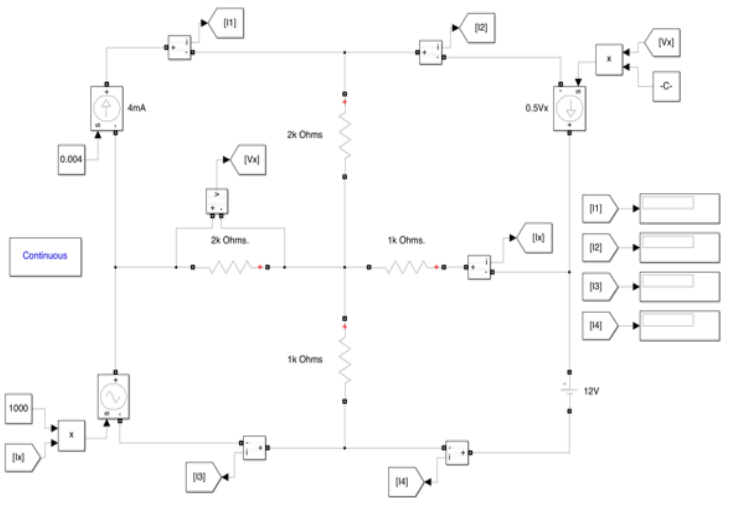

c

Fig. 3. Illustrative examples with different difficulty levels in Direct Current (D.C.) circuit analysis; *a*) D.C. circuit with independent sources, *b*) D.C. circuit with dependent current sources, and *c*) D.C. circuit with different dependent sources

C. Study Procedure

Student Performance-based assignments were designed and conducted by the course lecture as shown in Figure 2. In the first week, the fundamental of circuits and Ohm's law, the assignment was randomly chosen for each student with the same difficulty level. For the next week, the students, who make at the least score, could choose the assignments, providing in three difficulty levels: Normal, Difficult, and Very Difficult shown in Figure 3, with different score levels.

The students must upload a recorded PowerPoint presentation video to the Google Classroom, a learning platform that aims to simplify creating, distributing, and scoring assignments. The circuit analytical mistakes of students were discussed with the class each week.

D. Statistical Analysis

Data collection refers to the weekly results of students analyzing electric circuits using conventional circuit analysis techniques and MATLAB® Simulink – a computer simulation software package. In order to analyze the pre-post CSL in relation to each student's self-efficacy, the data collection to measure the improvement in electric analysis was calculated using a four-week moving average function. It represents a past average to predict long-term trends. Its directions illustrate the self-efficacy of individual students. Another metric shows recurrent learning – the relationship between weekly scores and the number of views of the videos. This confirms that students need to improve their self-efficacy after the online class.

III. Results and Discussions

Based on the cohort of 18 students enrolled in the Electric Circuit Analysis unit in 2021, the student self-efficacy results were analyzed as illustrated in Figure 4. It shows that students were able to score very well during the 1st - 3rd weeks. The partial content in the beginning course overlaps the content of a high-vocational degree – the previous degree of the student. In the fourth week, the continuous content is more and more difficult. The fundamentals of electric circuit analysis are extended from the previous content. The fourth week's average score (blue line) of students considerably drops. It shows that student self-efficacy underperforms their existing performance. With the content of the videos tailored by a course lecturer, the students attempt to study with MATLAB® – a computer simulation program for engineering. Students have improved their self-efficacy with progressive scores. Since the sixth week, students have overcome their existing and current achievements. Finally, the student self-efficacy outperforms the long-term average of the entire semester.

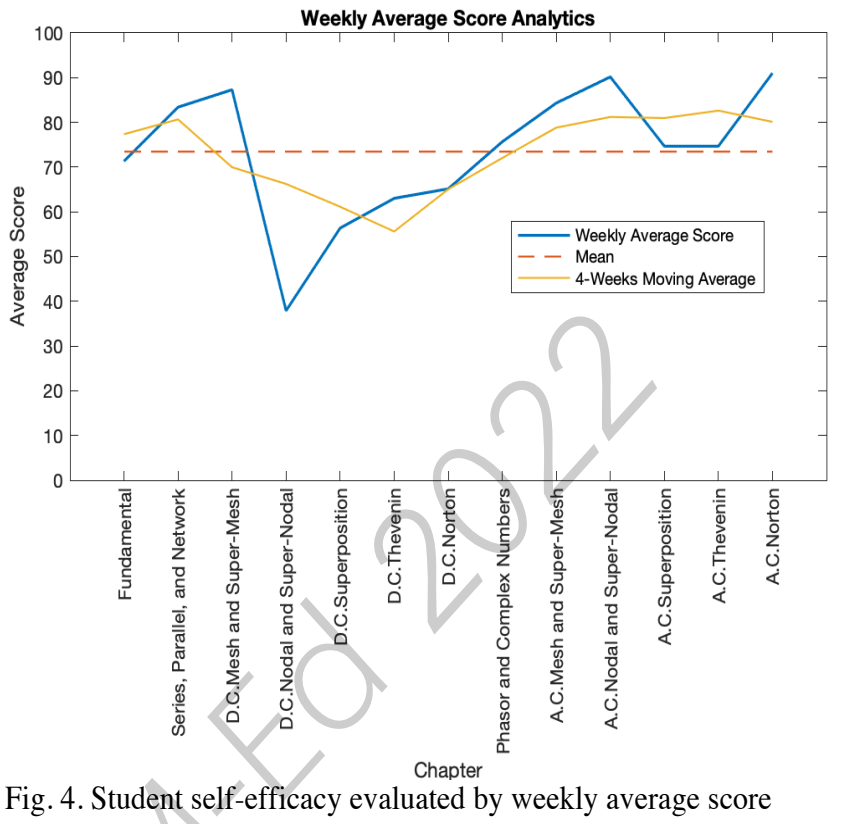

Fig. 4. Student self-efficacy evaluated by weekly average score

Fig. 5. Relationship between weekly scores and the number of video views.

The analytics with weekly scores divided by the number of video views each week reveals the rate of self-learning through clip videos could improve student self-learning as shown in Figure 5. Interestingly, the number of video views in the 3rd week is lower than expected. Based on our student interviews, we found that most students have excellent capability in circuit analysis by using the Mesh analysis. On the other hand, students have never analyzed circuits with the Nodal method. The number of views soars by 4.3 times of average scores in the next week, but the score of students underperformed. We have discussed the assignments to see weaknesses and strengths. Also, strengths parts have been brought up while weaknesses

have been eliminated. It is evident that students could make higher scores with less video attention when compared with the last week and could learn better with less time. It is concluded that our videos could help the student to get more understanding in calculating and analyzing circuits with MATLAB® Simulink.

IV. Conclusion

The results of the self-efficacy were clearly positive with significant improvement to student self-efficacy. CSL can guarantee the provision of consistent and diverse learning experiences and include exposure to scenarios that are engineering unusual, promoting a more equitable learning experience for all students. Students also reported that they appreciated CSL to be a wealth of learning experience.

Acknowledgment

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P02345

An Open Framework for teaching Motion Control for Mechatronics Education

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Abstract

This paper proposes the introduction of a novel open prototyping framework that involves using low-cost commercial off-the-shelf (COTS) components and tools for the module of motion control, within mechatronics education. The goal of this study is to propose a novel structure for the motion control module in the engineering mechatronics curriculum. This is accomplished by integrating students in a series of well-organised theoretical lectures as well as hands-on, highly engaging laboratory group projects. Surface learning parts and deep learning sections are combined frequently to encourage learners to grasp, make connections, and expand their knowledge. The structure of the course as well as the key topics are discussed. The proposed open framework, which consist of an elevator model, is presented in details.

Keywords— education, mechatronics, hands-on learning, framework

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***Abstract*—This paper proposes the introduction of a novel open prototyping framework that involves using low-cost commercial off-the-shelf (COTS) components and tools for the module of motion control, within mechatronics education. The goal of this study is to propose a novel structure for the motion control module in the engineering mechatronics curriculum. This is accomplished by integrating students in a series of well-organised theoretical lectures as well as hands-on, highly engaging laboratory group projects. Surface learning parts and deep learning sections are combined frequently to encourage learners to grasp, make connections, and expand their knowledge. The structure of the course as well as the key topics are discussed. The proposed open framework, which consist of an elevator model, is presented in details.**

***Index Terms*—education, mechatronics, hands-on learning, framework.**

I. Introduction

Motion control is a branch of automation that encompasses the systems and subsystems involved in the controlled movement of machine parts. Precision engineering, micromanufacturing, biotechnology, and nanotechnology are just a few of the fields where motion control systems are widely used for automation [1]. The key components involved with motion control usually include an energy amplifier, and one or more prime movers or actuators. There are two types of motion control: open loop and closed loop. The main focus of motion control is the specific automation control of motion systems with electric actuators such as DC/AC servo motors. Control of robotic manipulators is also considered as part of the field of motion control because the majority of robotic manipulators are driven by electrical servo motors and the primary goal is the control of motion.

In this work, a novel organisation of the *motion control* module for the engineering mechatronics education curriculum is presented. The aim is to inspire a new approach to teaching the course. Inspired by our previous work [2], [3], [4], this study intends to address the following research question: can thoroughly alternating surface and deep learning sessions increase understanding, activate relationships, and enhance students' knowledge? The basic idea is to organise the course into three parallel levels: (i) lectures that combine theory and exercises; (ii) laboratory; (iii) applications, in particular, an elevator model is prototyped.

The presented course is *MAS246-G* [5]. This course is a 5th semester module of the three years bachelor's degree programme in Mechatronics [6] given at the Department of Engineering Sciences, Faculty of Engineering and Science, University of Agder (UiA), Grimstad, Norway. Recommended previous knowledge for the course includes *MAS239* Feedback Control Systems 1, *MAS134* Electrical circuits and digital engineering, *MA178* Mathematics 1, *MA-179* Mathematics 2, or equivalent. This article outlines the overall structure of the course as well as the primary themes.

The paper is organised as follows. Section II depicts the course overview, while the laboratories are presented in Section III. Section IV describes the selected elevator model. The proposed architecture for the elevator model is presented in Section V. Finally, Section VI contains the conclusions and recommendations for further studies.

II. Course overview

The course material includes 12 theoretical lectures, 12 laboratory classes, and one course project. Each 6-hour theoretical lecture is held once a week and followed by a weekly 6-hour laboratory session. The following is a list of the topics covered in each lecture:

- Lecture 1: introduction on direct current (DC) machines;
- Lecture 2: DC machine's various drive circuits and operations;
- Lecture 3: modelling of a DC motor as thermal system;
- Lecture 4: stepper motor types and working principles;
- Lecture 5: control methods for stepper motors;
- Lecture 6: brushless DC electric motors;
- Lecture 7: permanent-magnet synchronous motors (PMSM);
- Lecture 8: rotary to rotary motion transmissions;
- Lecture 9: rotary to translational motion transmissions;
- Lecture 10: shaft selection and sizing;
- Lecture 11: lead-lag compensators;
- Lecture 12: modern motion control architecture.

III. Laboratories overview

The laboratory sessions run in parallel with the theoretical lectures introduced in Sect. II.

Programming in practice: Arduino

The goal of this lab is to introduce the use of Arduino [7] as a developing platform for motion control. Motion control necessitates a number of skills and abilities that can be easily developed using tools such as Arduino.

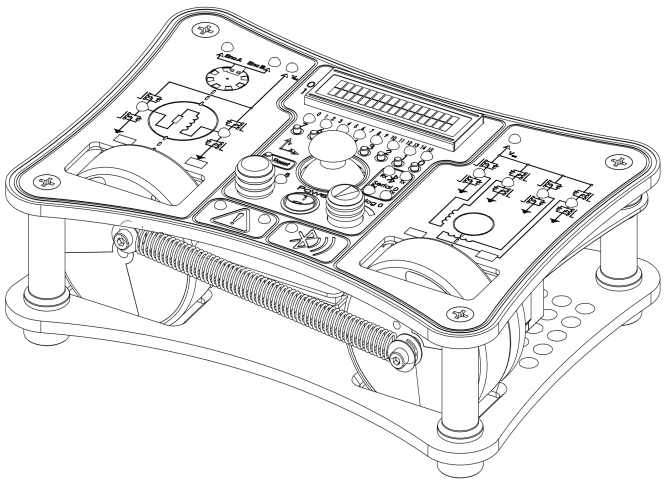

Fig. 1: The all in one servo lab (AIOSL).

Unified modelling language (UML) and class exercise

An introduction of the Unified modelling language (UML) is given with particular emphasis on embedded systems. Different diagrams are introduced including use case diagrams, class diagrams, sequence diagrams, and state machine diagrams [8]. These diagrams are meant to support the design and development of the course project.

All in one servo lab (AIOSL)

To facilitate the learning process for students, we have designed a novel platform for doing practical laboratory assignments, simulations and demonstrations. The development of this platform is based on the following key requirements: i) ease of use, plug and play (PnP), and ii) students engagement, so that working with the platform should be fun. To meet these requirements, we have developed a single unit platform with servo and stepper motor, various inputs and feedback options. This platform is named "all in one servo lab" (AIOSL) [9] and it is shown in Figure 1. Among other components, the AIOSL embeds two motors: a brushed DC motor and a two-phase stepper motor, respectively. This allows students to develop multi-function applications. The DC motor gives students the possibility to design software for motor control and to utilise lead-lag regulation. For closed loop control, feedback from the embedded encoder is necessary. This application challenges the students' ability to regulate micro-stepping. The components of the AIOSL are integrated in the chassis, while also providing a functional design. In fact, the motors are exposed through the top panel, giving a more visual perception of their status and allowing the students to affect their flywheels.

From a hardware perspective, an Arduino Mega [7] is integrated into the AIOSL.

IV. Elevator model

The course project aims at designing a complete elevator system to be implemented based on the AIOSL.

A. System requirements

As shown in Figure 2, the system controls a single-cabin elevator that travels up and down in a building with a set number of floors. The system requirements are summarised in Table I [10]. Based on these system requirements, the system features are mapped to the hardware and software components.

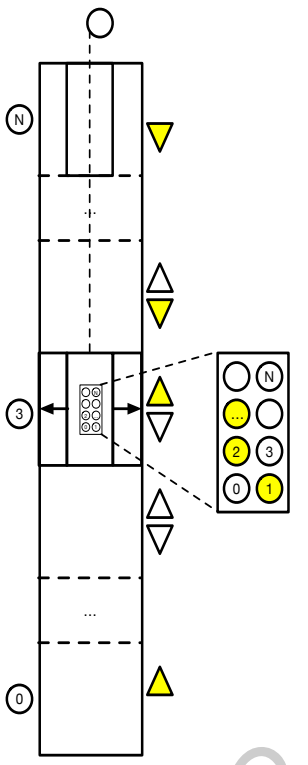

Fig. 2: An elevator system model with 0 to N floors, including a car, cables, an elevator machine, controls drive, cabin buttons and floor buttons.

TABLE I: System requirements.

REQ 1	The system controls the movement of an elevator.
REQ 2	The number of floors is set.
REQ 3	The elevator is either going up or going down.
REQ 4	The elevator is driven by a motor which can be either WINDING, UNWINDING, or STOPPED.
REQ 5	If not at the top floor, the cabin moves up one floor if the motor is WINDING
REQ 6	If not at the bottom floor, the cabin moves down one floor if the motor is UNWINDING
REQ 7	The cabin has a door which can be OPEN, HALF, or CLOSED.
REQ 8	While the cabin is moving, its door must be closed.
REQ 9	On each floor except the top one, there is an "up" button.
REQ 10	On each floor except the bottom one, there is a "down" button.
REQ 11	Inside the cabin, there are floor buttons, one for each floor.
REQ 12	The cabin stops at a particular floor and opens the door if there is a request to serve at that particular floor.
REQ 13	The requests at one floor are cleared once the door is fully open.
REQ 14	The elevator should not move to leave a floor if there are requests to serve at that floor.
REQ 15	The elevator should stay stationary at a floor when there are no requests.
REQ 16	The elevator can only change direction if it has no requests in the same direction, but has some requests in the opposite direction.

Elevation maps the requirements of WINDING, UNWINDING. Physical doors are implemented to more closely simulate a real elevator. There is an external cabin caller, and floor buttons inside the cabin. The model is also equipped with a floor indicator to visualise the current position. Although not strictly required, the elevator also includes a path optimiser for an efficient management of the elevator queue.

V. Proposed Architecture

A. Hardware design

For the elevator to take use of its functions, students are engaged in mapping these features into hardware components.

TABLE II: Mapping table for elevator model.

Feature	Hardware		Software
	Sensors	*Actuators*	
Elevation	Ground floor switch	Stepper with threaded rod	
Doors		Servo	
Floor buttons inside cabin	Button (7-2)		
Floor indicator		LCD-Screen	
Cabin-caller	Potentiometer for selection, buttons (1-0) for up and down	LCD-Screen	
Path-optimizer			Queueing system

For elevation (WINDING, UNWINDING), a stepper motor with a threaded rod is utilised. A mechanical switch indicates when the elevator hits the ground floor. For the doors, a servo motor is adopted. The floor buttons have sensors corresponding to each floor. The cabin caller is equipped with a potentiometer to externally select the floor, and with an LCD screen, also for floor indication. Even though a mapping to hardware components is prioritised, some features may alternatively be implemented in software. For example, the path optimiser is ruled by a queuing system implemented via software. The overall mapping of the elevator features is shown in Table II.

Referring to Figure 3, wires are connected in the stand to the stepper motor, ground switch and servo motor. The stepper motor is used in a 4 pole configuration, although the hardware supports 6 poles. The AIOSL has a built-in stepper motor drive (DRV8813) for directional control [9], and a DAC (MCP4922) for control of the current, hence the motor torque. The stepper motor in the AIOSL is connected with a one-by-four female wire head, which makes it easy to switch it out with the wires coming from the elevator model. To connect the servo and the ground switch, the extra pinheads which are implemented in the AIOSL are used. There are two two-by-five pin headers, each with a 5 volt pin and a ground pin. According to [9], the pin D12 is connected to the ground switch and D15 to the servo. The wire connection between the servo motor and the elevator model is pulled through the printed skirt, up through drilled holes on the second and third floor, and finally through a hole in the back of the cabin.

B. Mechanical design

The model's availability is a crucial consideration. Components and production methods that are readily available are

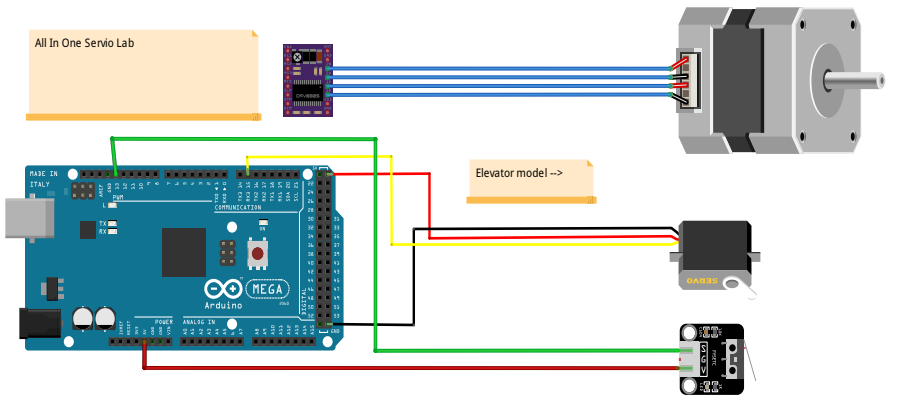

Fig. 3: Connection from the AIOSL to the elevator model.

TABLE III: Mechanical components for the elevator model.

Article	Material	Size	Qty.	Comment
Threaded rod	Steel	Ø 8mm - 470 mm	1	
Lead nut	Brass	Hole 8 mm	1	
V-slot Rat Rig profile	Aluminium	20x20x500 mm	1	
Threaded rod	Steel	M5 - 500 mm	4	
Nut	Steel	M5	8	
Flex axle	Steel	3mm - 8 mm	1	
Lock nut	Steel	5 mm	4	
Tube spacer	PLA	70 mm	24	3D-printed
Short tube spacer	PLA	25 mm	4	3D-printed
Stepper spacer	PLA	42x42x18 mm	1	3D-printed
Bottom skirt	PLA	152x102x68 mm	1	3D-printed
Cabin + cabindoor setup	PLA		1	3D-printed
M3 machine screw	Steel		4	
Bottom floor	Acrylic	150x100x4 mm	1	Laser cut
Mid floor	Acrylic	150x100x4 mm	6	Laser cut
Top floor	Acrylic	150x100x4 mm	1	Laser cut
Door servo			1	
Stepper motor			1	17HS4401
Wires				

used for components and for the prototyping process. The floors are made in acrylic sheets, which are laser cut in the right shape. The elevator cabin components including doors, the bottom skirt and a mounting spacer for the stepper motor are 3D-printed. All metal parts are easily available off the shelf in hobby shops and some components in hardware stores.

In Table III, all the mechanical components needed for setting up the elevator model and integrating it with the AIOSL are described. An exploded view of the elevator model is shown in Figure 4. The threaded rod with a diameter of 8 mm is the type used for controlling the z axis of 3D printers, and is usually available as spare part in most shops selling 3D-printers. The M5 is a standardised threaded rod, and four of them are used for holding the assembly together. The V-slot is a standard RatRig profile. This part may be switched with most profile rods. Small adjustments of the profile on the elevator cabin to fit the selected profile would be necessary.

The main tower part of the elevator model is assembled by

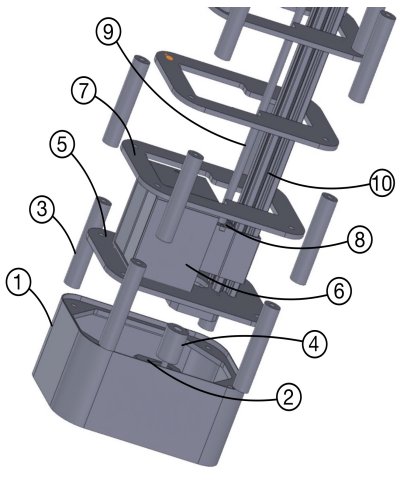

Fig. 4: Exploded view of the elevator model: (1) Bottom skirt, (2) Stepper motor, (3) Tube spacer, (4) Flex axle, (5) Bottom floor, (6) Cabin + Cabin door setup, (7) Mid floor, (8) Lead nut, (9) Threaded rod, (10) V-slot RatRig profile.

first mounting the lock nuts at the end of four M5 threaded rods, and placed in the corner holes from the underside of the stand. The bottom floor plate is then threaded on the rods and placed down in the fitted area in the stand. The stepper is then mounted from the underside with the M3 bolts through the bottom plate and the stepper spacer. This is to make sure that the shaft has the correct height above the plate for the flex axle to be mounted. The ground switch is mounted on the side of the spacer with two screws entered through pre-made holes, making sure that the switch is triggered by the elevator at the bottom floor. Finally, the v-profile is attached to the bottom plate with a 5 mm screw from the bottom in a crescent shaped trail on the stepper spacer. The rest of the floors are then assembled by putting a spacer on each rod and a mid floor section. This is repeated six times creating all the floors. The assembled elevator cabin is then slipped on to the profile and screwed down into the lead nut. Finally, the short spacers are mounted on the rods followed by the top plate, which is secured with two nuts on each rod.

The elevator cabin consists of a main body, two doors and a top section, containing the door mechanism and a servo. The door mechanism is operated by a servo pulling a fishing line through guiding poles on the doors, which again are held up by two rubber bands. The assembly is mounted to the cabin body with four M2 machine screws. The servo is connected by a servo wire through a hole at the bottom two mid floors and then the bottom plate.

C. Software design

In Figure 5 the UML Class Diagram of the elevator model is depicted. The "DAC" class is specialised for using the DAC unit, which controls the current connected to the stepper driver. This is necessary because of the old type of stepper driver implemented in the AIOSL. Similar explanation applies for the "Jmstepper" class too, as this is meant for a driver where the coils are activated separately. The remaining classes are created to accommodate the remaining specifications. The "Elevatordoor" class steers the door servo and keeps track of its current state, simultaneously as it stores the set boundaries for the door. The "Switch" class is used to set up multiple switch inputs as elevator cabin buttons, as well as the floor buttons on the outside. These two are passed along to the "Floorchooser" class, which together with the "Potensiometer" class, passes the selected floor for the queue if up or down buttons are pushed. The "Elevator" class is connected to both the "Elevatordoor" and "Jmstepper" class, as well as the "LCD" class. As the "LCD" class is used in both "Elevator" and "Floorchooser" the LCD object has to be created in the main control process and provided for both classes. The "Queue" class is a queuing operator.

VI. Conclusions and Future Work

This study introduced a comprehensive syllabus of the motion control module for the engineering mechatronics curriculum. The module blends a series of organised theoretical sessions with practical and highly engaging laboratory exercises. The course culminates with a group project that focuses on the implementation of an elevator model. The pedagogical effectiveness of the proposed prototype is evaluated based on the students' feedback. In the future, students' feedback will be collected to improve their learning experience and the quality of the provided teaching offer.

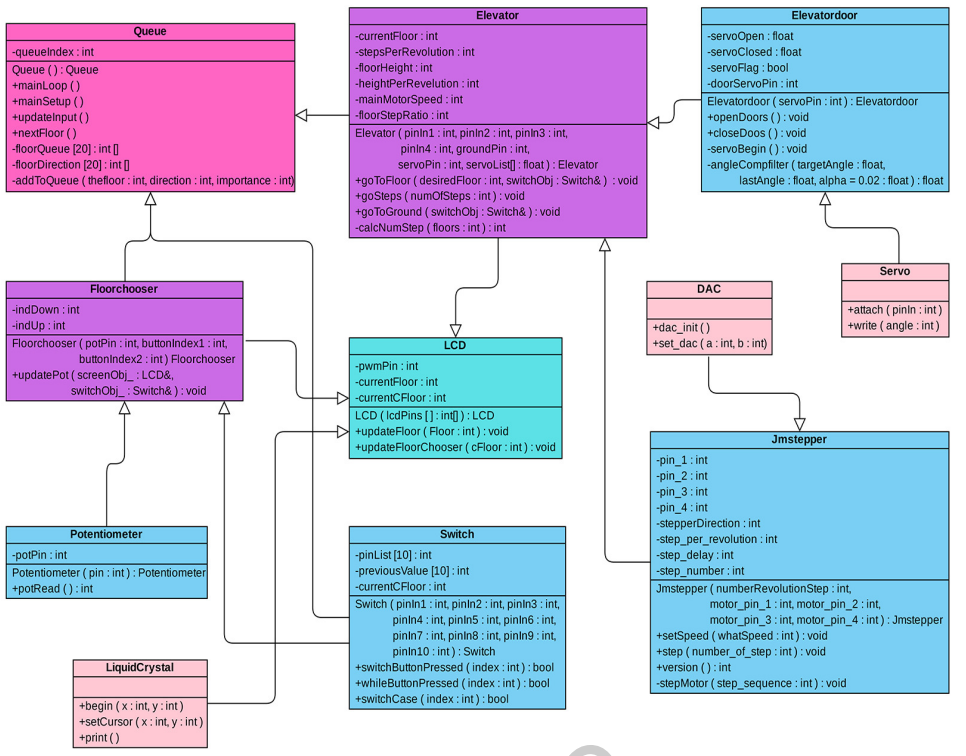

Fig. 5: UML Class Diagram for the elevator model.

Appendix A
Elevator Open Source Repository

The elevator open source repository is available on-line at https://github.com/Microttus/Elevator-model/.

Acknowledgment

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P02362

Estimating Number Line as a Cause of Low Mathematics Performance in Zambia

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Abstract

This study aimed to examine the cause of low mathematics performance in Zambia. It hypothesizes that one of the reasons for low performance is skills in number line estimation. Therefore, we have conducted a survey in Zambia. The results demonstrate that several pupils possess high calculation skills with appropriate number line estimation skills, high calculation skills without estimation skills, low calculation skills with accurate estimation skills, and low calculation skills without accurate estimation skills. The study then compared the feature of these types of pupils. The result indicates that a sense of the half or the middle of a number line is important. Moreover, certain pupils with low calculation skills have the sense, which suggested a possibility in understanding calculation easily compared with pupils without this sense. Moreover, these estimation skills

are called mental number lines in developmental psychology. It is the foundation of mathematical skills such an addition and subtraction. Therefore, improving the mathematics performance of Zambian pupils is necessary to improve their ability to estimate number lines as mental number lines.

Keywords— Zambia, Low Mathematics Performance, Number Line, Estimation, Number Sense

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Estimating Number Line as a Cause of Low Mathematics Performance in Zambia

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***Abstract*—This study aimed to examine the cause of low mathematics performance in Zambia. It hypothesizes that one of the reasons for low performance is skills in number line estimation. Therefore, we have conducted a survey in Zambia. The results demonstrate that several pupils possess high calculation skills with appropriate number line estimation skills, high calculation skills without estimation skills, low calculation skills with accurate estimation skills, and low calculation skills without accurate estimation skills. The study then compared the feature of these types of pupils. The result indicates that a sense of the half or the middle of a number line is important. Moreover, certain pupils with low calculation skills have the sense, which suggested a possibility in understanding calculation easily compared with pupils without this sense. Moreover, these estimation skills are called mental number lines in developmental psychology. It is the foundation of mathematical skills such an addition and subtraction. Therefore, improving the mathematics performance of Zambian pupils is necessary to improve their ability to estimate number lines as mental number lines.**

Keywords—Zambia, low mathematics performance, number line, estimation, number sense

I. INTRODUCTION

Numeracy in the Sub-Sahara Africa region ranks lowest in the world [1]. Furthermore, the mathematics performance of pupils in the Republic of Zambia (Zambia) ranks last in the Southern and Eastern Africa Consortium for Monitoring Educational Quality [2]. Therefore, improving the quality of mathematics in Zambia is an urgent issue. A large-scale survey may be able to reveal the low performance of mathematics achievement in Zambia; however, small-scale studies are still required to elucidate problems in detail [3]. One of such issues reported is the disconnect between mathematics contents in textbooks and daily life in African countries [4]. Mathematical concepts are abstract concepts; therefore, children frequently need to rely on the real world or daily life to understand them. Moreover, a research cited that mathematical concepts are created by metaphors [5]. Based on these reasons, this disconnection is a serious problem. As a mathematical concept, negative numbers are uncountable numbers, such that a metaphorical understanding is needed. Therefore, the study conducted a survey that focused on integers and metaphors. As a results of previous survey, we have found (1) low calculation skills in integers, (2) lack of ability of learners to compare negative numbers with those encountered in daily life, and (3) understanding of number lines and their significant impact on calculation ability [6]. Based on these results, the current study intends to determine one of the aspects of low achievement by evaluating the understanding of pupils about number lines. This is the research question in this research. Hence, the objective of the study is to examine how pupils understand number lines.

II. RESEARCH METHODOLOGY

A. Materials

The study selected questions related to number lines with modifications from an item bank for number sense (Figure 1) [7]. Number sense is considered the foundation of mathematics. Furthermore, the study conducted simple calculation test on the addition and subtraction of integers (i.e., 4 – 8, 2– (–4)) as an indicator to determine the difference between pupils with and without calculation skills. The questionnaire consists of items on number lines and a calculation test (24 items).

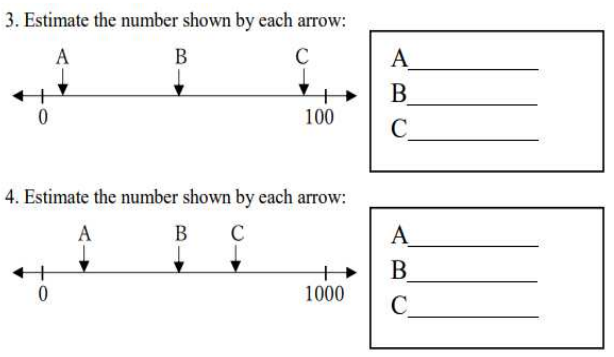

Fig. 1. Modifated questions on number lines

B. Outline of the survey

We conducted a survey from March 22 to 31, 2019, at Lusaka, the capital city of Zambia. The study recruited 75 pupils in Grade 8 who finished learning integers. The questionnaire was disseminated to all pupils. According to the test scores, the study selected pupils for interviews to further enhance the understanding of number line.

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III. RESULT

A. Result of calculation test

Table I presents the result of the calculation test.

TABLE I. RESULT OF CALCULATION TEST
(N = 75, AVERAGE OF % CORRECT 60.06, SD = 17.5636)

Questions	% Correct	Questions	% Correct
4+2	93.33	2+6	96.00
6−4	90.67	4−8	45.33
−8+4	84.00	−6+8	54.67
−4−2	48.00	−2−6	49.33
4+(+2)	70.67	2+(+6)	70.67
8+(−2)	61.33	4+(−8)	65.33
−4+(+2)	66.67	−4+(+8)	49.33
−6+(−2)	58.67	−2+(−6)	62.67
8− (+2)	57.33	4−(+6)	44.00
6− (−2)	66.67	2−(−4)	50.67
−4− (+2)	36.00	−2−(+6)	34.67
−6− (−2)	46.67	−6−(−8)	38.67

In general, the average score of % correct 60.06 is not to understand sufficiently. Moreover, % correct of questions involving negative numbers, such as 4+2, 6−4, and 2+6, exceed 90%. Therefore, the problem may lie in their understanding of negative numbers.

B. Result of questions for number lines

The results indicate that regardless of the high or low % correct, certain pupils displayed accurate and inaccurate estimation.

C. Result of interviews

Based on the calculation test and number line questions, the study classified pupils as shown in Table Ⅱ for interviews to determine the differences.

Fig. 2. Interviews

TABLE II. CLASSIFICATION OF PUPILS

Test score % correct	Number line estimation	Test score % correct	Number line estimation
P1: 100%	Accurate	P4: 66.7%	Not accurate
P2: 100%	Not accurate	P5: 29.2%	Accurate
P3: 66.7%	Accurate	P6: 29.2%	Not accurate

An example question in the interviews is "How did you judge the number on the number line?" Feature of P1 is answered B is the middle, so he judges B as 50 and 500 (Fig. 3).

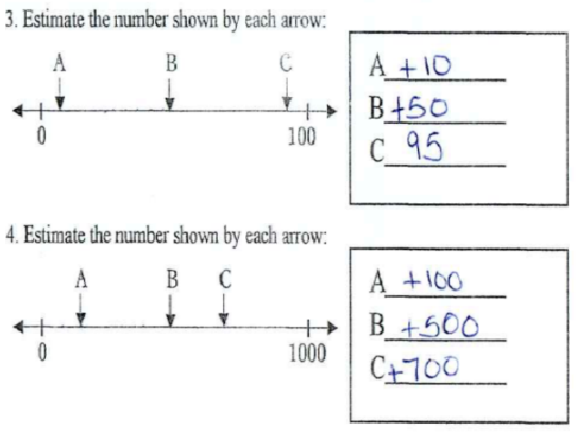

Fig. 3. Response of pupil P1

Fig. 4 presents another example, where the number line estimation of P2 was inaccurate. However, he also answered that point B is median (50). Moreover, he answered that 3C is 99, because it is next to 100. When asked, "What is the median of 0 and 1000?", he changed the answer to A: 250, B: 500, and C: 650.

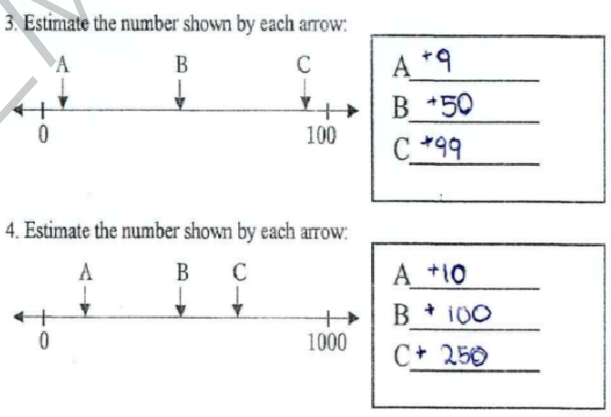

Fig. 4. Response of pupil P2

Fig. 5 depicts that P3 pupil answered that point B is median. However, his response for 3A is 25; thus, we asked, "What is the median of 0 and 50?" to which he replied "25."

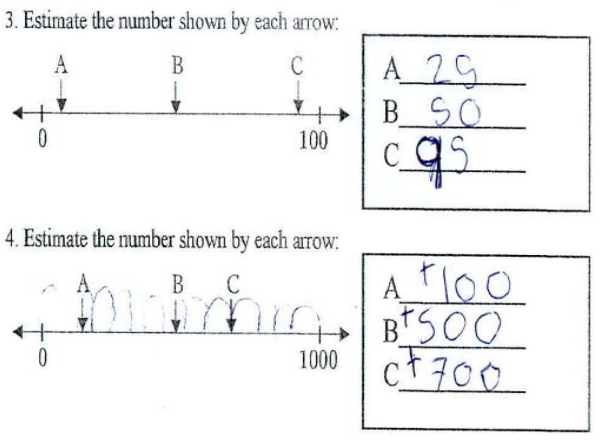

Fig. 5. Response of pupil P3

Fig. 6 presents the responses of P4, who is always counting from 0. After counting, he changed 100 to 90 on the 0-to-100 number line. His response for 4A, 4B, and 4C is 30, 90, and 120, where he counted from 0

using his scale of 10. Moreover, we asked "What is the median of 1000?" to which he responded, "I don't know."

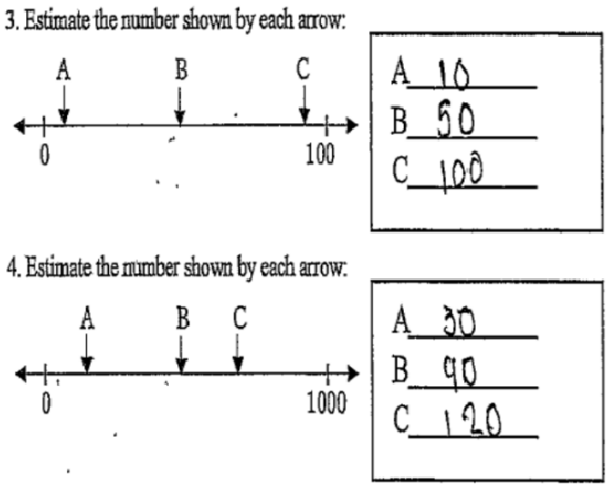

Fig. 6. Response of pupil P4

P5 mentioned that point B is in the middle. Thus, we asked, "If 3A is 10, then is C 99?" after which he changed his answer to 90. Furthermore, he answered that 4A is estimated at 200, because the scale of number line is 0 to 1000 (Fig. 7).

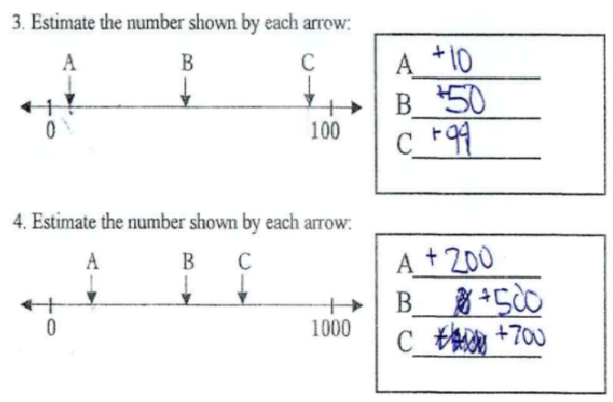

Fig. 7. P5 pupils' answer

P6 pupil tends to count from 0. According his scheme, 3A is 1, where he counted his scale up to 3B. He then responded that 3C is 99, because C is found immediately before 100. We then asked "What is the median of 0 and 100?" to which he responded "50." Moreover, we asked, "What is 3B?" He started counting from 0 and answered 9. Furthermore, on the 0-to-1000 number line, he cited 4A as 991, because 1000 is found on the right. We asked "What is half of 1000?" He answered 500; thus, we asked, "What is 4B?" He started counting from A as 991 and answered 996 (Fig. 8).

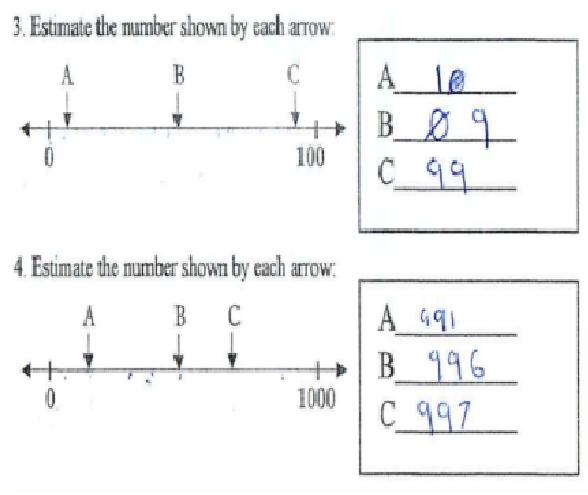

Fig. 8. Responsesn of P6

IV. Discussion

Based on the result, the study argues that the accuracy of estimating number lines is dependent on one's sense of the halfway or the middle point. Moreover, without this sense, the pupils tend to count from 0 using their unique scales. Initially, we assumed that high-performance pupils can estimate number lines well. However, several low-performance pupils exhibited accurate estimation skills, such as P5. Hence, we hypothesize that low-performance pupils with accurate estimation, such as P5, can easily understand the lesson.

Therefore, P3, P4, P5, and P6 underwent a lesson on integers, which lasted for approximately 40 min by the first author.

Fig. 9. Lesson on integeres conducted by the first author

The lesson focused on number lines and techniques for solving addition and subtraction of integers.

Table III presents the result of changes in the test scores.

TABLE III. Comparison of Test Scores

	% Correct before	% Correct after	Difference
P3	66.7	83.3	16.6
P4	66.7	70.8	4.1
P5	29.2	91.7	62.5
P6	29.2	37.5	8.3

Based on the result, the % correct of all pupils have increased. Moreover, the % correct of P5 has highly increased. Therefore, a possibility exists that the accurate estimation sense of number lines is the foundation of mathematics performance. From the perspective of developmental psychology, one's ability in number line estimation is measured using the number line task. Moreover, the ability to estimate number lines is called mental number line. Furthermore, a widely known fact is that a positive correlation exists between the accuracy of the mental number line and math performance [7]. Additionally, the use of reference points for number lines (beginning, middle, and end) is also known as an indicator of mental number line [8]. Moreover, the number of reference points increases according to the mental development. In relation to the results, P1, P3, and P5, can identify the beginning, middle, and end points. However, P4 and P6 can only pinpoint the initial point of the number line. For these reasons, the

underdevelopment of the mental number line is the cause of low mathematics performance. A simplified lesson plan is presented as shown Table IV.

TABLE IV. SIMOLIFIED LESSON PLAN

Time	Teacher	Pupils
~5 min	will show the right(+), left(−) with drawing number line.	will be able to understand the opposite.
5 min ~15 min	will show the calculation without blankets with drawing number line. eg., 3+5=8, 3−5=−2, −3+5=2, −3−5=−8 will give some exercise as follows. eg., 3−7=, −3+7=, −3−7=	will be able to understand the simple calculations. will be able to solve some exercise with number line.
15 min ~20 min	will explain the techniques of how to solve addition and subtraction of integers. 1. how to open blankets. +(+)=+, +(−)=−, − (+)=−, − (−)=+ 2. how to move on the number line after open blankets.	will be able to understand the how to open the blankets.
20 min ~40 min	will show the how to open blankets and how to calculate addition and subtraction. +(+)=+,+(−)=− − (+)=−,− (−)=+ eg., 3− (+5)=3−5=−2, 3−(−5)=3+5=8 will give some exercise as follows: eg., −3− (+5)=, −3− (−5)=	will be able to solve some exercise.

V. CONCLUSION

The study found that the accurate estimation skills of pupils may lead to several combinations, such as pupils with and without accurate estimation skills not regardless of their proficiency in calculation skills. Moreover, we found that identifying the reference points of number lines is an important factor for understanding and estimating number lines. In addition, another possibility exists that pupils with accurate estimation skills of number lines have the potential to understand integers. Furthermore, we pointed out that the cause of low performance may be the underdevelopment of mental number lines. However, this study has its limitations. The first is that the number of interviews and experimental lessons of the pupils is few. The second is that we hypothesized that the cause of low mathematics performance may be the underdevelopment of mental number lines. However, this study does not to examine other details. Therefore, future studies should focus on mental number lines to examine the underlying reasons for the cause of low performance in Zambia and other areas in African countries. Moreover, the current study challenges the academe to improve the mental number lines of pupils. Certain studies mentioned that using computers with game function, physical movement, and virtual reality are efficient for improving mental number lines [9][10]. Therefore, the study recommends that future studies should develop tools with the intention of improving their mental number line.

VI. ACKNOLWGEMENT

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Pedagogy for Applying Mathematical Principles in Software Engineering

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Abstract

Software engineering educators face the challenge of conveying the relevance and importance of mathematical principles to system requirements specification, analysis, and design. There have been attempts to address this issue and this report presents an example of one such attempt. The approach taken here is a research-based software engineering course that implements formal specification techniques, as an integral component of the curriculum. The expected outcome is that the students will acquire skills in applying mathematical concepts in a seamless manner.

Keywords— Unified Modeling Language, software engineering, safety-critical system, pedagogy,formal specification Metaverse

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Pedagogy for Applying Mathematical Principles in Software Engineering

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***Abstract*— Software engineering educators face the challenge of conveying the relevance and importance of mathematical principles to system requirements specification, analysis, and design. There have been attempts to address this issue and this report presents an example of one such attempt. The approach taken here is a research-based software engineering course that implements formal specification techniques, as an integral component of the curriculum. The expected outcome is that the students will acquire skills in applying mathematical concepts in a seamless manner.**

Keywords—Unified Modeling Language, software engineering, safety-critical system, pedagogy, formal specification

I. INTRODUCTION

Software engineering is plagued with failures such as the Therac-25 radiation machine [1] and the Boeing 737 MCAS onboard aviation system [2] that make the headline, as opposed to the many successes onboard avionic collision avoidance system TCAS [3] and the James Webb space telescope system [4] that are less publicized. Software system failures become significant when they are safety-critical systems [5]. Safety-critical software systems are characterized by their failure resulting in harm or death to personnel. Development of such systems has to be conducted with methodologies that ensure reliability and correctness of system analysis, design, implementation, and testing. This is best accomplished when the developers have the requisite skillset to conduct the necessary techniques.

The acquisition of the aforementioned software development skillset can be accomplished at the graduate level of education. The pedagogy presented in this report acknowledges the need for a more scientific approach to software engineering. One such approach is the use of formal (mathematical) specification [5] in the specification, analysis, design, and testing of safety-critical software systems. In this report, an example of a research-based project for a graduate course in software engineering is presented. The description of the research effort was contained in an associated term report that each student had to submit

II. COURSE DESCRIPTION

A. Course Description

This course teaches software engineering principles and techniques used in the specification, design, implementation, verification, and maintenance of large-scale software systems. Major software development methodologies are reviewed. As development team members, students participate in a group project involving the production or revision of a complex software product. After successfully completing this course, students should be able to:

- Identify and apply software engineering principles in building models of large complex systems within a CASE tool environment.
- Demonstrate knowledge of software development methodologies for safety-critical systems.
- Understand formal notations and their use in software development.
- Document software development activities.
- Apply various software testing techniques.
- Participate in team development.
- Conduct software engineering research.

Students will have to submit a term paper that should be in a publishable format and quality. Students will identify a research topic of interest, submit a title, and abstract. The term paper, of no less than eight (8) pages, will be submitted by the end of the semester.

III. STUDENT REPORT

The UML (Unified Modeling Language) [6] is a graphical modeling language used to specify, simulate, and construct software system components. The UML has been adopted and standardized by the Object Modeling Group. In this paper, the UML class diagram is consider, which is the most fundamental and widely used among all UML models. A Class Diagram provides a static description of system components. The purpose of a class diagram is to display classes with their attributes and methods, hierarchy (generalization) class relationships, and associations (general, aggregation, and composition) between classes in one model [7].

UML is considered the standard for object-oriented software model development that allows modeling various aspects of complex systems. However, there are many concepts in the UML with imprecise semantics which limits the use of UML and reduces the quality of the UML models. Thus, developing technologies of analysis and verification of UML model is significant to developers who use UML to model their systems.

A model designing process can include a large number of designers who are prone to making mistakes which gives rise to potential conflicts, uncertainty, and overlapping. Also, the development of these models is highly time intensive process. It is extremely important to check the correctness of these models and state the problems in the early stage of the software design process.

An approach to resolve this problem is to simplify the semantics of the class diagram concepts through the application of mathematical formality to the definition and usage of these class diagram concepts. The applicable mathematical principles result in a reduction of complexity in the UML class diagram and leads to a better understanding of the model. Eliminating redundant components reduces the complexity associated with UML class diagram models. The mathematical principles applied in this work are from the domains of set theory and predicate logic, which are particularly relevant for the development of software systems that require a high level of reliability.

The main goal of this research is to verify the correctness of generated UML class diagram models. In order to accomplish that as a first step, we are attempting to reduce the number of concepts in developing class diagram models. The focus here is to remove generalization by applying mathematical principles and set theory and then apply standard graph theorems to identify mathematical incorrectness in the structure of the model. This work identifies the first step reported in this paper. This research will be helpful in terms of time, cost, effort, and error handling in the field of automatic code generation (program synthesis systems) and can be applied to various safety-critical systems.

IV. RESEARCH BACKGROUND

This section covers some of the theories and prior work in the area of UML model transformation and mathematical representation of such models.

A. Unified Modeling Language (UML)

The Unified Modeling Language (UML) [6] has been widely accepted as the standard language for modeling and documenting software systems. Their significance has enhanced with the beginning of the Model-Driven Development (MDD) approach, in which analysis and design models play an essential role in the process of software development. In this work the UML is used because of its dominance in software development and the ease of understanding accorded to the students.

B. UML Class Diagram

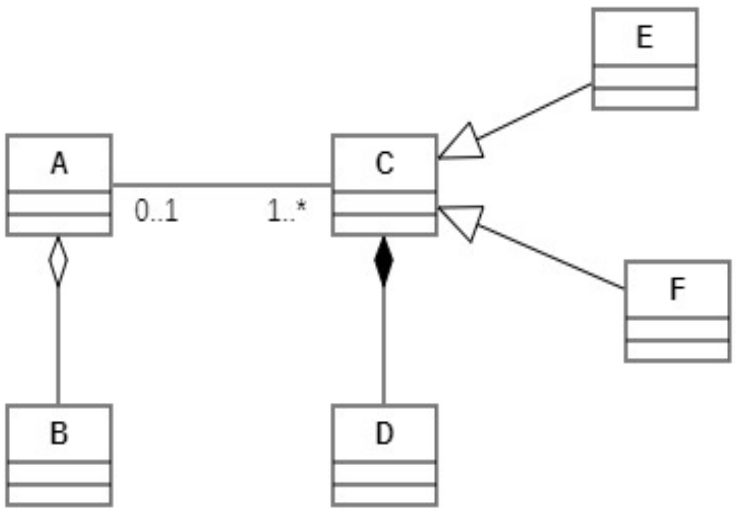

Fig. 1. UML Class Diagram

Class diagrams are used to represent the static structure of system components [6]. It describes the structure of system in terms of classes, attributes, and constraints imposed on classes (operations) and their inter-relationships.

Classes in UML models are represented as rectangles. Each class consisting of a name, set of attributes, and set of operations on the class's attributes. Fig. 1 shows an example of a class diagram consisting of classes, associations (aggregations and compositions), and generalizations.

There are some rules and requirements for combining the classes to construct partial or complete UML class models.

Association: It indicates the possible relationship between the class entities [8]. An association represent events that involve attributes and objects from the related classes, such as the relationship between class A and class C seen in fig. 1. Association ends can be annotated with label names and multiplicities. Multiplicity can be expressed as specific numbers, ranges of numbers, or unlimited numbers as shown in Fig. 1 between classes A and C.

Aggregation: An aggregation is represented as an association with a white diamond on one end, where the class at the diamond end is the aggregate (container class) and it includes or owns instances of the class (contained class) at the other end of the association [8] (e.g., relationship between class A and B in fig. 1).

Composition: It is a special type of association, in which instances of the contained class are constructed from instances of the container classes [8]. For instance, Fig. 1 shows class C consists of E and F. It is represented as an association with a black diamond.

Generalization: A generalization is represented by an association with a triangle on one end represents, where the class at the triangle end of the association is the parent class of the classes at the other ends of the association, called subclasses [8]. A subclass inherits all of the parent class's attributes, operations, and associations (e.g., subclasses E and F inherits properties of parent class C in Fig. 1).

TABLE I. RELATION DEFINITION [6]

Function		Constraints		
Name	***Symbol***	***dom f***	***1 - 1***	***ran f***
Total function	→	= X		⊆ Y
Partial function	⇸	⊆ X		⊆ Y
Total injection	↣	= X	Yes	⊆ Y
Partial injection	⤔	⊆ X	Yes	⊆ Y
Total surjection	↠	= X		= Y
Partial surjection	⤀	⊆ X		= Y
Bijection	⤖	= X	Yes	= Y
Partial bijection	none	⊆ X	Yes	= Y
Finite partial function	⇻	⊆ X		⊆ Y
Finite partial injection	⤕	⊆ X	Yes	⊆ Y

C. Set Theory and Relationships

The goal of this work is to reduce the number of concepts used in the development of class diagram models. In order to do that, the aim is to eliminate generalization using mathematical concepts and set theory. Table 1 illustrates the name of the set theory function, as well as the corresponding multiplicity and a description of the relationship.

D. Course Research

This work attempts to reduce the number of concepts used to develop UML class diagram models. An approach to resolve this problem is to simplify the semantics of the class diagram concepts through the application of mathematical formality to the definition and usage of these class diagram concepts. The main goal here is to remove duplicity associated with the generalization relationship by applying mathematical principles and set theory.

In this approach, we are providing relational description of generalization and specialization relationship. In addition, we are using set theory to demonstrate mathematical equivalence of generalization and general association.

E. Generalization and Specialization in UML Class Diagram

In the object-oriented paradigm generalization and specialization is used to connect two model elements of the same kind. It specifies a relationship between a more general element and a more specific one to enhance reusability of model classes. The concept of generalization and specialization relationship is well understood when it is applied on classes. However, several contradictions and ambiguities arise when these concepts (i.e., generalization and specialization) is extended to other model elements.

A class diagram with a generalization and specialization relationship is shown in Fig. 2. The class A generalizes the classes B and C. In other way, we can say classes B and C are specializations or subclasses of class A. Here, classes B and C inherit the properties of class A. We are not considering abstract class in our approach.

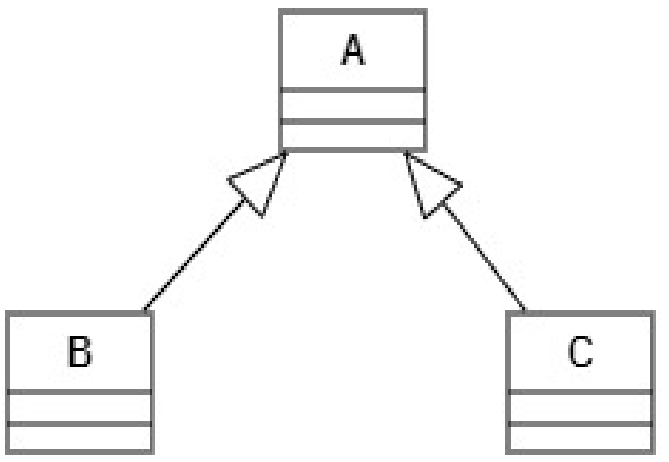

Fig. 2. Generalization and Specialization in UML Diagram

Fig. 2 is a reference in this section. To reduce the duplicity associated with UML class diagram concepts and to demonstrate generalization as a general association we define a relationship between parent generalize class and its subclass. In which members of class B (i.e., subclass) maps bijection relationship (GAB) with element of class A (i.e., generalize class). That also implies that if all attributes (a1, b1) of the classes A and B belongs to GAB then a1 must equal to b1. The bijection relationship between classes A and B is shown in the equation below:

$$GAB = \forall (a1, b1) \in GAB \rightarrow a1 = b1$$

The same way members of class C (i.e., subclass) maps bijection relationship (GAC) with element of class A (i.e., generalize class). That also implies that if all attributes (a1, c1) of the classes A and C belongs to GAC then a1 must equal to c1. Bijection relationship (GAB, GAC) involves both one-to-one and onto function. The bijection relationship between classes A and C is shown in the equation below:

$$GAC = \forall (a1, c1) \in GAC \rightarrow a1 = c1$$

F. Set Theory to Demonstrate Mathematical Equivalence

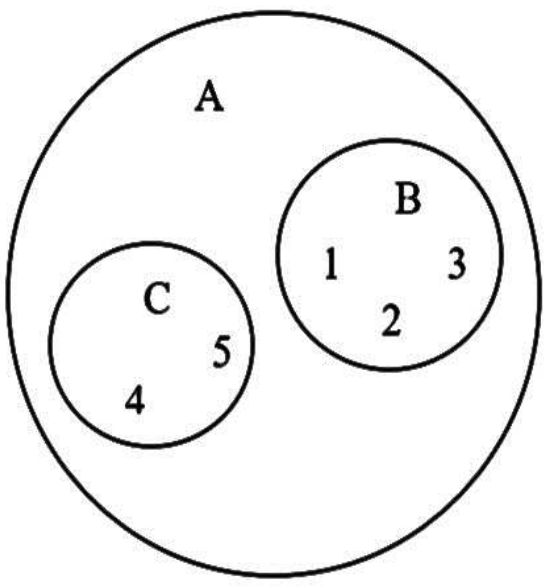

Fig. 3. Venn Diagram

Set theory is the mathematical theory of well-defined collections of sets and objects that are called members or elements of the set. In this section, we use set theory to demonstrate the relationship between sets and prove their equivalence using Venn diagram. The purpose of Venn diagram is to show logical relationship between sets.

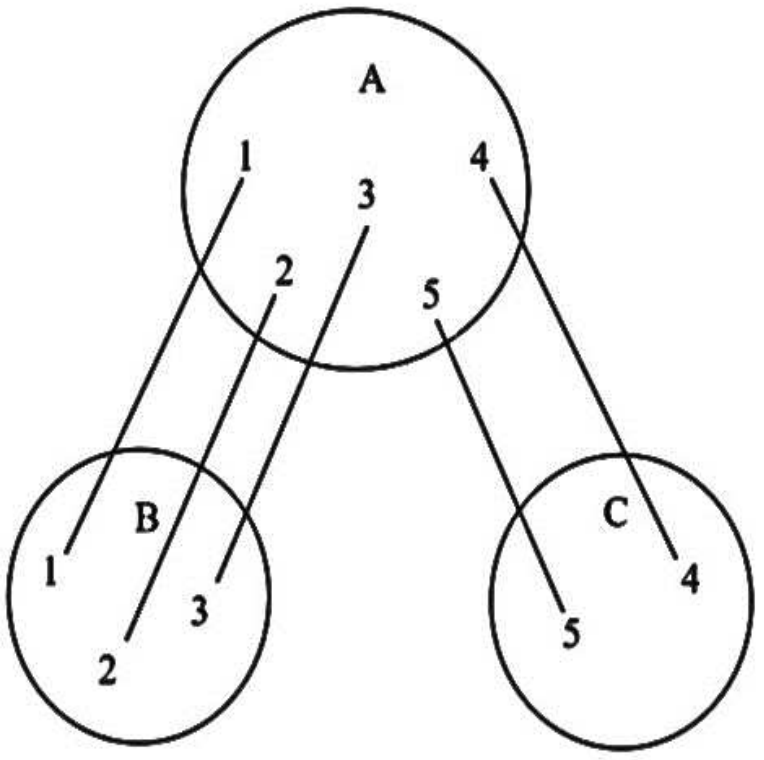

Fig. 4. Relational Venn Diagram

Fig. 3 represents sets A, B, and C in a Venn diagram. Set A = {1, 2, 3, 4, 5}, B = {1, 2, 3}, and C = {4, 5}. Sets B and C are subsets of set A since all of their elements are also elements of set A. In addition, sets B and C are disjoint sets, as they do not share any common elements.

The relational Venn diagram induced by Fig. 3 is shown in Fig. 4. It maps the relationship between sets A, B, and C. The set A forms a bijection relationship with sets B and C. All elements of set A can be put in a one-to-one correspondence with the elements of sets B and C. Relationship between sets A and B can be written as a1 = b1, a2 = b2, and a3 = b3. The same way a4 = c4 and a5 = c5 reflect the relationship between sets A and C.

The relationships demonstrated for generalization and specialization as a general association is equivalent to relationships of sets represented by Venn diagram.

V. STUDENT REPORT CONCLUSION

The relational Venn diagram induced by Fig. 3. is shown in Fig. 4. It maps the relationship between sets A, B, and C. The set A forms a bijection relationship with sets B and C. All elements of set A can be put in a one-to-one correspondence with the elements of sets B and C. Relationship between sets A and B can be written as a1 = b1, a2 = b2, and a3 = b3. The same way a4 = c4 and a5 = c5 reflect the relationship between sets A and C.

The relationships demonstrated for generalization and specialization as a general association are equivalent to relationships of sets represented by Venn diagram.

VI. CONCLUSION AND FUTURE WORK

This approach to having students learn how to apply formal specification techniques, by way of researching the mathematical foundation for informal software modeling concepts will be beneficial by the development of skillsets that:

Incorporate mathematical techniques for precise and correct development of safety-critical software systems,

Foster greater appreciation of the use of mathematics in software engineering, and

Make a contribution to the body of research that attempts to move software engineering from a domain of artisan effort, into the realm of a true field of engineering [9].

Further research into the pedagogical approach of research-focused learning for the specification, analysis, design, and testing of safety-critical software systems will include comparative studies of courses in which other approaches are applied with that of the approach presented in this report. Such studies will provide quantitative indication of what the benefits of this approach are versus that of other approaches.

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P02355

Collaborative Learning Model for Identifying Competence Gap of Self-Employed Worker in Local Community

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Abstract

The COVID-19 outbreak, along with Thailand's current economic situation, has resulted in population displacement, with young employees returning to their hometowns and starting their own businesses constituting the largest group of migrants. This project proposed a collaborative learning model for students and young self-employed people to work together to identify the skills required to be self-employed in the local community, with the assumption that after graduation, students will return to their hometowns and one of their professional options will be to start their own business or work as self-employed workers. The proposed learning model was evaluated with multidisciplinary students from the University of Phayao and young self-employed employees in Wieng Lo village, Chun district, Phayao province, Thailand. The model's main concept is to allow

students and self- employed people to share their knowledge and experience, and then to collaborate on identifying key competences for self-employed workers in their community. The real-world experience of the workers and the professional knowledge of the students can help each other fill up the gaps. The results of identifying competency gaps can be utilized to create an upskilling or reskilling course that will fulfill the needs of future workers. Workers can use this information to plan their own self-directed learning. Students can also learn from professionals' experiences about the vital competencies they possess so that they can grow themselves before graduating.

Keywords— Collaborative learning model, Self- employed workers, Lifelong learning, Competence gap

Collaborative Learning Model for Identifying Competence Gap of Self-Employed Worker in Local Community

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***Abstract*— The COVID-19 outbreak, along with Thailand's current economic situation, has resulted in population displacement, with young employees returning to their hometowns and starting their own businesses constituting the largest group of migrants. This project proposed a collaborative learning model for students and young self-employed people to work together to identify the skills required to be self-employed in the local community, with the assumption that after graduation, students will return to their hometowns and one of their professional options will be to start their own business or work as self-employed workers. The proposed learning model was evaluated with multidisciplinary students from the University of Phayao and young self-employed employees in Wieng Lo village, Chun district, Phayao province, Thailand. The model's main concept is to allow students and self-employed people to share their knowledge and experience, and then to collaborate on identifying key competences for self-employed workers in their community. The real-world experience of the workers and the professional knowledge of the students can help each other fill up the gaps. The results of identifying competency gaps can be utilized to create an upskilling or reskilling course that will fulfill the needs of future workers. Workers can use this information to plan their own self-directed learning. Students can also learn from professionals' experiences about the vital competencies they possess so that they can grow themselves before graduating.**

Keywords*— *Collaborative learning model, Self-employed workers, Lifelong learning, Competence gap

I. INTRODUCTION

In Thailand, the COVID-19 epidemic situation and the current economic situation in the country caused the relocation of the population in the country in 2020 to as high as 10.5 million people. The largest group of migrants in the provinces is youth workers aged 15-24, about 31 percent, as most of them work in fields affected by COVID-19 [3]. The immigration of a new generation of knowledgeable and technologically savvy young people back to agriculture could be an opportunity to make a positive change in the community. If the community has a strong base, has good resources, and has a strong community financial position, this younger generation may help build economic security for the community [4]

Self-employment is on the rise around the world. The proper interpretation of this new trend will result in reduced poverty and unemployment among university graduates. They have started new firms as a result of the rising unemployment rate and their desire to be financially independent [5]. According to various research, There is a relationship between economic development, entrepreneurship, and economic growth. Entrepreneurship appears to have a crucial role in the development of diverse economic structures and processes of invention production [6]. Entrepreneurial skills such as creativity, initiative, tenacity, teamwork, risk awareness, and a sense of responsibility are all important. This entrepreneurial mindset helps entrepreneurs put their ideas into action while also increasing their employability.

Several studies have focused on entrepreneurship education for higher education students in order to provide them with the knowledge and skills they need to become self-employed workers after graduation [7]–[10]. Due to the rapid change in the world, people must constantly learn new things to keep them up-to-date with the knowledge and skills that are essential for their careers and income. Learning and developing entrepreneurial skills is important for working people of all ages.

The concept of self-directed learning has great importance as a tool for lifelong learning [11]. It is a process in which people take the lead in figuring out what they need to learn, setting goals, finding

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resources, and so on. They can do this alone or with the help of others.

This project proposed a collaborative learning model enabling students and young self-employed people to work together to get the skills they need to be self-employed. The idea is that when students graduate, they would return to their hometowns, with one of their job options being to start their own business or work for themselves.

The next section gives an introduction of the learning model, outlining how constructive alignment can be used to define learning outcomes, learning styles, and evaluations for learners. In order to tailor learning outcomes to the context of each group, the design separates participants into two groups: student groups and young self-employed groups.

II. METHODOLOGY

A. Research Site

The proposed learning model was implemented with a third-year University of Phayao students and young self-employed workers at Wieng Lo village, in the Chun district of Phayao province, Thailand. Wieng Lo village is an agriculture-based community. It also has a historical attraction, the Wieng Lo ancient site, which is a tourist attraction that generates additional income for the community from being a tour guide and spending in the community of tourists.

The detail of each group is described in the following section.

B. Learners description

Learners in this project are divided into 2 groups: third-year students from multidisciplinary programs and young self-employed workers in the local community.

1) A total of 54 third-year students from four programs, including eight from Digital Marketing, twenty from Communication Management, fourteen from Physics, and twelve from Electrical Engineering.

2) A total of 18 self-employed workers in Wieng Lo village, aged between 23 and 42 years old. The most common self-employed worker's occupation is Agriculture. Their supplementary income comes from serving as a community guide for ancient places in Wieng Lo and local tourism in the Lo area. They also sell things created in the area, such as local food, handicrafts, and so on.

C. Preliminary Information

Prior to designing the learning process, preliminary information concerning the strength, gap, and learning goals of each group is collected by interviewing students and young self-employed workers in local community, as shown in Table I. The strength of one group can fulfill the competence gap of the other group. This information was used as a guideline for designing the learning model.

D. Designing learning model

Based on the assumption that one of the career options for students when they graduate is to have their own business or be self-employed in their hometown, we use the preliminary information in Table I to design a learning model in which one group's strengths can help compensate for the other group's lack of skills. The constructive alignment framework [12] serves as the foundation for the learning model. The process is as followed.

1. Identify the learning outcomes of each group.
2. Design an assessment to measure the learning outcome.
3. Design the collaborative activities so that both learners develop their skills and knowledge based on the learning outcomes.

The constructive alignment framework of the proposed collaborative learning model is shown in Fig. 1. The learning outcomes for students consist of a technical skill outcome and a personal skill. The learning outcome and assessment of technical skills are based on their courses and were set by the instructors. Personal skills or soft skills were evaluated by instructors and students self-assessed. The learning outcome for young self-employed workers proposed in this paper is able to identify their competence gap, which is the first step of the self-directed learning approach.

TABLE I. PRELIMINARY INFORMATION

Issues	Students	Self-employed workers
Strength	- Gain knowledge and skills specific to the profession by studying the course.	- Have the insights from experience - Learn from trial and error
Competence gap	- Lack of skills to understand problems to find the real problem -Lack of experience to connect professional knowledge with real-world applications	- Lack of updating the knowledge or skills necessary to develop a better career - Requires specific skill related to career - various levels of education and learning abilities with different learning styles
Learning goal	to graduate and pursue professional career	-Develop skills to enhance their career -Create social stability

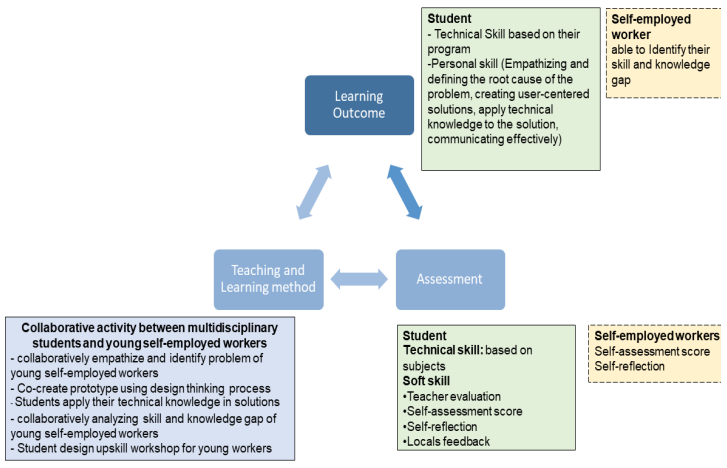

Fig. 1 Constructive Alignment of the proposed collaborative learning model

The teaching and learning method proposed in this model is a collaborative activity between multidisciplinary students and young self-employed workers. Students and workers collaboratively empathize and identify the problem of being self-employed workers in the local community. Next, they co-create a prototype using the design thinking process. These steps are to develop systematic thinking and problem-solving skill of both groups. Next, students must apply their technical knowledge to solution which allowed them to apply their professional knowledge to the real-world problem.

Throughout the collaborative activity, self-employed people shared their experiences, concerns, and solutions, which served as a real-life education for students on what skills and attitudes are crucial in the real world. Self-employed workers were also introduced to students' professional expertise, which helped them evaluate what new skill or knowledge would be beneficial to their job and what they wanted to upskill or reskill.

After having experience with understanding problems and testing solutions, they collaboratively analyze skills needed for self-employment in their local community and discuss the current competence gaps of young self-employed workers, which can be used to define learning goal and choose an appropriate learning style later on.

In this paper, we focused on presenting the results of analyzing competences needed for self-employment in the local community and the competence gap of young self-employed workers in Wieng Lo village.

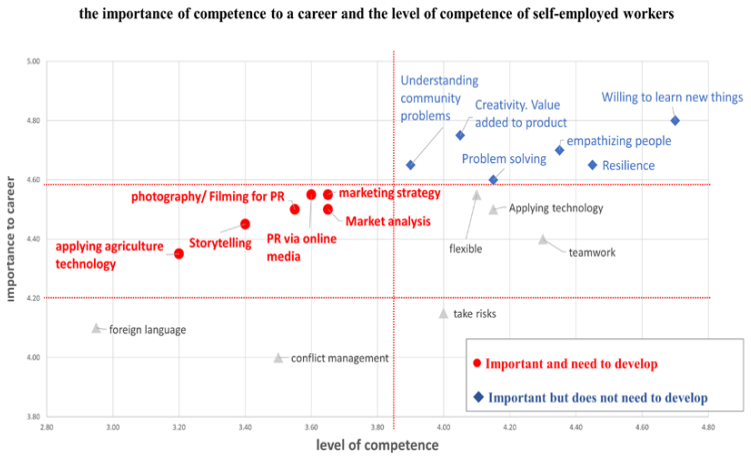

Fig.2 relationship between the importance of competence to a career and the level of competence of self-employed workers

III. Results and Discussion

After students and young self-employed workers collaborated to empathize with the problem, the 18 critical competences were identified as shown in Table II. To identify the competence gap of self-employed worker in local community, the workers were asked to evaluate each competence in two categories: 1) The value of each competence in terms of career or financial benefits is rated on a scale of 0 to 5, with 0 denoting no value and 5 denoting significant value. 2) A self-evaluation of their competence level on a scale from 0 to 5, with 0 meaning they have no skill and 5 meaning they are very skilled. Figures 2 show the relationship between the importance of competences to a career and the level of competences. This result was then manually classified into 2 classes: 1) competencies that are important but do not require development. These competences are scored as important, and most people already possess them. 2) competencies that are important and need to be developed since most people lack these competences.

The competencies that are important but do not require development is shown in the top right section of the plot in Fig.2 which consists of: willing to learn new things, understanding the situation and causes of problems in the community, creativity and be able to create new things or add value to current product/resource in community, problem solving skills and resilience.

The competencies that are important and need to be developed are shown in the middle-left section of the plot, which consists of: marketing analysis and strategy; photography and filming a video for PR; public relations through online media; storytelling; and applying agriculture technology such as renewable energy, smart farming, and modern agriculture machines. The important competencies that self-employed workers should develop are the professional competencies, which are the students' expertise. Students will use these results as a guide to develop the upskilling/reskilling course that meets the needs of workers in the future.

After performing a reflection with students, most students mentioned that the important competences students need to develop to prepare themselves as self-employed workers in the future are resilience, understanding community problems, teamwork, problem solving, and creativity to add value to products and resources available in the community.

IV. Conclusion

This paper proposed a collaborative learning model for identifying the competence gaps of self-employed workers in their local community. The assumption is that when students graduate, they will return to their hometowns. Having their own business or being self-employed is one of their career choices.

The core of the model is to allow students and self-employed workers to share their experience and expertise, and then they work together to identify the important competencies for being self-employed

workers in their hometown. The workers' real-life experience and the student's professional knowledge can fill in the gaps for each other.

The findings from identifying competency gaps can be used as a guide to develop an upskilling or reskilling course that meets the needs of workers in the future. The workers can also use this result to plan for their self-directed learning. Students also learn from the experience of workers about the important competences that the workers have so that students can develop themselves before they graduate.

ACKNOWLEDGMENT

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P02334

Applied Learning of Python based Arduino with Kiddee lab's STEM Kit-1 (KiddeeSTEM1)

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Abstract

Embedded Technology is played an important role in many industrial applications, such as process control, Mobile robots, Real-Time processing and data logging. In the new era of Internet of Things (IOT), embedded systems are incorporated with smart sensors and actuators in many applications. To train youngster on coding skills using Python for embedded system, it is essential to have attractive modules with light, sound, or movement. Arduino is a processor that is common and readily available and easy to use. STEAM Kiddee Lab Skills Enhancement School has modules and syllabus for youngster to understand the concept of embedded system containing LED, 7-Segment, Buzzer, Tac/Dip Switch, Potentiometer, LDR, RGB and DC Motor. The syllabus is using Python programming to control Arduino on the Kiddee lab's STEM Kit-1 (KiddeeSTEM1).

Keywords— Arduino, Coding, Embedded system, Python Programming, STEM kit.

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Applied Learning of Python based Arduino with Kiddee lab's STEM Kit-1 (KiddeeSTEM1)

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***Abstract*— Embedded Technology is played an important role in many industrial applications, such as process control, Mobile robots, Real-Time processing and data logging. In the new era of Internet of Things (IOT), embedded systems are incorporated with smart sensors and actuators in many applications. To train youngster on coding skills using Python for embedded system, it is essential to have attractive modules with light, sound, or movement. Arduino is a processor that is common and readily available and easy to use. STEAM Kiddee Lab Skills Enhancement School has modules and syllabus for youngster to understand the concept of embedded system containing LED, 7-Segment, Buzzer, Tac/Dip Switch, Potentiometer, LDR, RGB and DC Motor. The syllabus is using Python programming to control Arduino on the Kiddee lab's STEM Kit-1 (KiddeeSTEM1).**

Keywords—Arduino, Coding, Embedded system, Python Programming, STEM kit.

I. INTRODUCTION

In 2007, Apple Company Limited had released a new portable technology called "iPhone" – smartphone, in the world. It had a significant modification in technology, by dramatically improving the embedded equipment. Technology is one of the key factors that drive the new systems in the world such as Cloud Computing, Internet of Things (IoT), Embedded System, Artificial Intelligent (AI), Machine Learning, etc. [1].

The new generations, Y and Z will interact with others and the physical world through electronics devices, smart phone / tablets and computers via social media, software and Applications which is known as "Digital Native", [2]. Kiddee Lab Company Limited acknowledges the importance of exposing the technologies in embedded system to youngster so they can learn them via basic coding, block-based language and script programming languages [3]. Kiddee lab has focused on STEM Education which uses coding with Python programming on Arduino - Kiddee Lab's STEM Kit-1 (KiddeeSTEM1); containing LEDs, 7-segment, buzzer, relay, push button, dip switch, potentiometer, LDR sensor, RGB LED, and DC motor.

There are four parts in this paper. First part is introduction, the second part describes the systems for KiddeeSTEM1. The third part contains experiment and results of this research. Conclusion is stated in fourth part of this paper

II. SYSTEM CONFIGURATION

A. Software and Protocol

Python programming is used as the main core for learning coding syntax, variables, functions, conditions and statements. Pyfirmata module is used to interface with Python and Arduino. Firmata protocol is used in microcontroller software to interact with computer via Python programming.

B. Hardware STEM kit

Fig. 1 shows Kiddee Lab's STEM Kit-1 (KiddeeSTEM1) which includes LEDs, buzzer, relays, 7-segments, tac switches, dip switches, potentiometer, LDR sensor, RGB LED and DC motor modules. The modules are given to the youth to learn coding interactively and efficiently without having to worry about circuit connections.

Fig.1 Kiddee lab STEM kit-1 (KidSTEM1)

B1. Arduino Uno

Arduino Uno is like a brain where the programs are executed, and logical decisions are made as per the command of the user. Arduino Uno is an advanced microcontroller board, with variety of electronic sensors and actuators. The board comes at a reasonable price and is easily accessible as well.

The Arduino UNO has been used in many senior projects of students and researchers and the authors have shared their many learning experiences [4]. The Arduino Uno is used as a main controller for KiddeeSTEM1.

B2. Light Emitting Diode (LED)

LED is the acronym of Light Emitting Diode; it is a diode that glows (transmits light) when electricity passes through it. It has a larger voltage drop than a conventional diode, ranging from 1.2 Volts for infrared LED to 3.5 Volts for blue and ultraviolet LEDs, [5]. There are two modules of LEDs in KiddeeSTEM1: four active high LEDs and four active low LEDs.

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B3. Buzzer

A sound-producing electronic device that is commonly used as an alert indicator. Buzzer is able to create sound with different tone (frequency, Hz) by means of the driver circuit [5]. A 5 Volts buzzer module is used as the sound indicator in the KiddeeSTEM1.

B4. Relay

Relay is used to control other devices (generally operating at higher voltages/current) by applying differential voltage. The maximum output current from an Arduino pin is 40 mA, and the total output current all five output pins is 200mA [6]. So, a driver is normally used to trigger the coil of the relay. There are two relays board on the KiddeeSTEM1: normally open (NO) and normally closed (NC). We use both of them for learning experience.

B5. 7-Segment

Electronic gadgets use seven-LED modules for numbers and characters, plus an eighth LED for the decimal point. Common cathode and common anode 7-segments boards are used in the KiddeeSTEM1 to provide a learning experience. Array of bits (vector) can be sent to display different numbers.

B6. Momentary/Alternate Switches [7]

A momentary switch (push or tac button) and an alternate switch (dip switch) are commonly used as input device for testing of coding on embedded system. These inputs can be used to determine whether a signal goes high or low depending on the state of switch. The main different are state of switch depends on the application of the types of input needed if input needs to be hold or not during the operation.

B7. Potentiometer

Analog reading plays an important role in the usage of embedded system. A simple knob can provide an adjustable resistance resulting in voltage variation; this can be the analog value to the Arduino's pin. Analog pins of Arduino Uno are specified. A total of four potentiometers available on the KiddeeSTEM1.

B8. Light-dependent Resistor (LDR) sensor

The resistance of an LDR sensor changes depending on the light that falls on the LDR's surface. Once the resistance changes, the voltage drop changes, which is transferred to the analog reading pins. This sensor can be used to create automatic lighting control system to the youth. In KiddeeSTEM1, a LDR module is provided which is related to the voltage and analog reading pin.

B9. RGB LED

A RGB LED is made up of three different LEDs: red, green, and blue. There are common cathode and common anode RGB LED. Different colors can be generated by applying a PWM signal to each pin of RGB LED. Each of the red, green, and blue values is stored in one byte (8 bits) format 2^8 = 256 of the compound color, [8].

B10. Mini DC Motor

The small DC motor is used to demonstrate concept of PWM's application. The students are able to practice controlling the speed and direction of the DC motor. A DC motor driver (H-bridge) is used to adjust the speed and rotate the motor in clockwise and counter-clockwise direction.

III. Experiment & Result

Kiddee Lab uses Integrated Development and Learning Environment (IDLE) platform for Arduino-Python Courses. It is easy to install and user friendly as well. Python is not supported by Arduino IDE, so, StandardFirmata needs to be downloaded and installed in Arduino Uno for Input/Output (I/O) and complier set up. Basically, Python communicates to Arduino via pyfirmata which has to be imported in the python code and StandardFirmata downloads to Arduino board via remote I/O.

In this section, relations of KiddeeSTEM1 to **S**cience, **T**echnology, **E**ngineering and **M**athematics (STEM) will be demonstrated.

A. Science

A1. Resistor

A resistor with the SI unit is Ohms (Ω), resists the flow of electrical current in a circuit. Using the resistor color code, the value of the resistor is denoted by 4-5 color band bands: The first 2 bands represent the value's initial two digits, while the 3rd band represents the power of ten that follows those two digits. This is the multiplier, which is the number of zeros that must be added. The last band represents the tolerance of the resistor, and it is usually silver or gold in color. [5]. The resistor value can be represented by [9]

A2. Voltage, Current, and Resistance

Ohm's Law states that the current (I) flowing through an electronic component is equal to the applied voltage (V) across the component divided by the resistance (R) as shown in equation (1), [9].

$$I = \frac{V}{R} \qquad (1)$$

In the training courses, a suitable current is calculated for the standard brightness of the LED and RGB LED.

A3. Buzzer

A buzzer is commonly used as a daily equipment to produce sound alert. It is a very useful for students to understand the operate on the buzzer module.

The Arduino Uno cannot drive the buzzer by itself, so, a driver circuit is essential. A transistor circuit is used as an amplifier, which will be explained next. The buzzer has a polarity and students needs to be aware about the connection. The connection of the buzzer circuit to Arduino Uno is illustrated in Fig. 2.

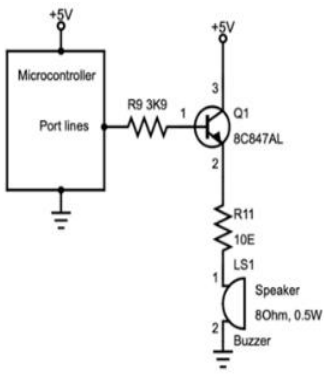

Fig. 2 Buzzer Circuit

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A4. LED

LED has polarity, cathode (negative symbol (-)) and anode (positive symbol (+)). The students need to be cautious on the polarity of LED when doing practical connection. There are two concepts regarding active high and active low which is important while programming which is illustrated in Fig. 3.

The current needed to operate the LED depends on the applied voltage source (V_S), which is 5V for our KiddeeSTEM1. The voltage across the LED (V_{LED}) and resistance are related as shown in equation (2). The standard LED current is 15mA.

$$I_{LED} = \frac{V_S - V_{LED}}{R_{LED}} \quad (2)$$

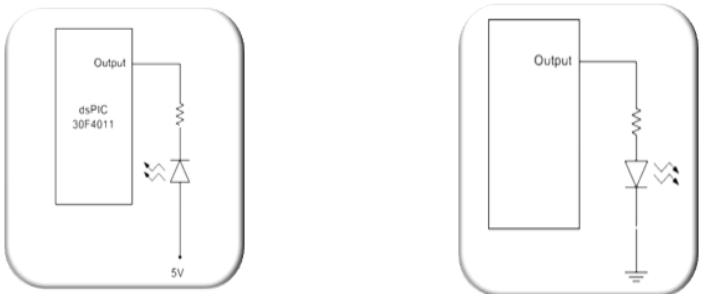

Fig. 3(a) Active High Fig. 3(b) Active Low

B. Technology

B1. Microcontroller (Arduino Uno)

There are various microcontrollers in the market. One of commonly used is dsPIC by Microchip. The dsPIC is a general-purpose microcontroller [10]. The development board is normally used as a starter in a project / research. The development board supports both +3.3 V and +5 V. With previous technology, the Joint Test Action Group (JTAG), a popular hardware interface is used to interface directly with the chip which used to communicate between the user's computer and chip [11]. JTAG is used as a downloader and debugger while testing different applications. As the technology has changed, Arduino Uno is commonly used for small projects / DIY. Nowadays, Arduino Uno can be easily programmed by a simple USB programming via serial communication.

The advantages of Arduino Uno are as follows:

1. Arduino Uno is cheap and easily obtained from the market.
2. Programming Arduino is easy; one can just download via USB cable.
3. Arduino PCB and layout is open source and downloading is free.
4. It is very easy to learn and implement. Ideal for small projects / DIY.

C. Engineering

C1. Python Programming

Python is a high-level language. Python is an attractive language in the year 2020. There are many modules which can be imported and used with Python.

There are other languages such as JavaScript, Pearl, C++ which are more complicated compared to Python [12]. Python's syntax is straightforward and easy to learn, making it ideal for new programmers.

Students can be logical Engineers with basic Python programming skills.

C2. Relay

The relay module is used to explain the concept of different applications with varying voltage levels. Coils and contacts need to be explained before we can properly write the program. How the contact is in action as current passes through the coil is described next. Normally Opened (NO) contact and Normally Closed (NC) contact can be chosen for a project. Fig 4 (a) and (b) illustrates the NO and NC operation of the relay.

Fig. 4(a) Normally opened contact relay

Fig. 4(b) Normally closed contact relay

C3. DC Motor

Students can learn the operation of a small DC motor in this section. The force created in a magnetic field drives the DC motor. The main idea behind the electromagnetics is that a coil of wire wound around a metallic rod, generates a magnetic field when current passes through it. Reversing the current changes the polarity of the electromagnetic field generated and thus the direction of the motor as well [8].

The speed and direction of rotation of a motor is controlled via H-bridge. H-bridge is constructed from two pairs of transistor switches, which are connected to the different polarity of the motor. The duty cycle of the wave can be set to control the speed of the rotation. Generally, the duty cycle is represented in percentage (%). Duty cycle is the ratio of the "on" period over "total – on plus off" period of the signal. Hence higher duty cycle results in higher voltage resulting in higher speed of the motor. The switching is "diagonally opposite" such that the direction of current through the motor controls the direction of the rotation.

Control of DC Motor								
Counter Clockwise (CCW)			Clockwise (CW)			STOP		
EN (%)	IN1	IN2	EN (%)	IN3	IN4	EN	IN1	IN2
0-100	1	0	0-100	0	1	0	x	x

Table. 1 Control of DC Motor

Table1 shows the operation of the H-bridge on the DC motor. EN represent the PWM duty cycle: 100% reflects the motor is operating at full speed. IN1 and IN2 convey the direction of the DC motor. For example, IN1 = 1 and IN2 = 0 will rotate DC motor counterclockwise and vice-versa. Motor can be stopped by applying EN = 0 or same logic to IN1 and IN2.

The DC motor module is included in the KiddeeSTEM1 for students to practice programing skills and physically control the direction and speed of the DC Motor.

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D. Mathematics

D1. LDR Sensor

LDR is used to sense the brightness of the environment. The LDR is connected by a voltage divider circuit. The result (V_{ADC}), from these two connections will not be the same and can be calculated by using the voltage divider concept. Voltage divider ideas from equation (3) and equation (4) are used to calculate and interpolate the ADC data which can be written in the Python program. Circuit of these two connections are shown in Fig. 5.

$$V_{ADC} = \frac{R_{Sensor}}{R_1 + R_{Sensor}} x\ 5v \qquad (3)$$

$$V_{ADC} = \frac{R_1}{R_1 + R_{Sensor}} x\ 5v \qquad (4)$$

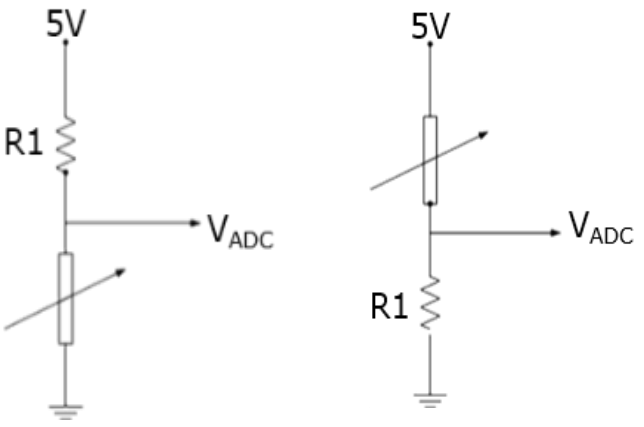

Fig. 5 LDR (a) on the bottom Fig. 5 (b) on the top

D2. RGB LED

There are two types of RGB LED: common cathode and common anode. The concept is similar to that of a normal LED (which was explained earlier). To operate the RGB color, an analog value is needed to be send. For example, a dark red color being set; the values of RGB are R = 157, G = 0 and B = 0. This data is then expressed in an 8-bit (0 to 255) format. The values are transmitted via PWM format and setting Pin R to be 157, Pin G to be 0 and Pin B to be 0. Hence, y will be displayed for the RGB LED. Through these kinds of exercises, the students will be excited and inspired to explore further with other colors on their own.

D3. Potentiometer

Potentiometer or variable resistance is used to demonstrate the concept of analog to digital converter (ADC). Arduino has 10-bit ADC which can be represented from a number 0 to 1023. When an analog voltage is supplied to a potentiometer, the voltages vary as the resistance changes. The analog data of 0 to 1023 will be read by Pyfirmata and displayed in Python from a range of value between 0-1.

During the experiment, students will be able to calculate the value from the ADC and compare it to the actual reading.

D4. 7-segment

There are two types of common cathode (CC) and common anode 7-segments. In CC the Ground is common whereas in CA the Voltage source is common. There are 7 Pins labelled a,b,c,d,e,f,g for the seven LED segment. A dp is decimal segment of the 7-segment. For CC, a high logic is needed to turn on a particular segment as the Common signal is ground and for CA, a low logic is needed to turn on a particular segment as the common signal is voltage source. Fig 6 illustrates the pins and arrangement of a LED 7-segment.

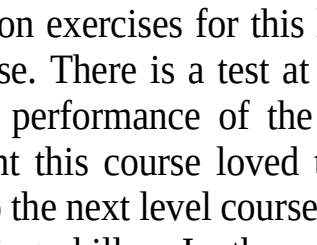

Fig.6 CC/CA 7-segment arrangement

IV. CONCLUSION

The objective of this research is learn Python programming via simple electronic circuits and outputs such as light, sound and relaying devices. These kinds of output are attractive for young students as they can see the results immediately and interact with the physical world and senses. The python program is interpreted by Arduino via pyfirmata protocol. Kiddee Lab's STEM Kit-1 (KiddeeSTEM1) includes modules of LED, Buzzer, Relay, 7-segment, Tac/Dip switch, Potentiometer, LDR Sensor, RGB LED and DC Motor. The user needs to write a code to make these outputs work as per the curriculum of Science, Technology, Engineering, and Mathematics (STEM).

During the class, there are exercises with calculations, flowcharts, and logical planning for students to analyze and understand deeply so they can be excellent engineers in future. There are 36 hours of training and hand-on exercises for this lively Arduino & Python - I course. There is a test at the end of the course to test the performance of the students. The students who learnt this course loved them and they wish to continue to the next level courses with requires further programming skills. In the next level, IOT concepts will be demonstrated via Python programming.

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Students' Interaction Level in Animation Learning Media Post on Facebook

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Abstract

Nowadays, the use of social media as a tool for learning has become an important role. The most popular SNS, Facebook has become one of the most popular platforms for learning. Moreover, using Facebook together with animation learning media could cause online learning efficiency for secondary school students in physics course. Also, with the use of information technology as an effective tool to collect the data. In this research, we study the level of students' interaction level in animation learning media that posted on Facebook. The finding indicates that at level 0 of students' interaction, students re-watch the animation learning media at 95% of video length is 15.51%. At level 1 of students' interaction, students have reaction feature to the animation learning media total at 55.17%. At level 2 of students' interaction is online discussion post which divide into different categories. It was found that the most online discussion post is asking question category, giving reason category and agreeing category at total post at 24.13%, 18.96% and 13.79% respectively. The finding could provide

new insights for the development of online learning and adjusting the learning process to study the student's online learning behavior and increase students interest and interaction in animation learning media for online learning.

Keywords— animation; digital media; online learning; social network

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***Abstract*— Nowadays, the use of social media as a tool for learning has become an important role. The most popular SNS, Facebook has become one of the most popular platforms for learning. Moreover, using Facebook together with animation learning media could cause online learning efficiency for secondary school students in physics course. Also, with the use of information technology as an effective tool to collect the data. In this research, we study the level of students' interaction level in animation learning media that posted on Facebook. The finding indicates that at level 0 of students' interaction, students re-watch the animation learning media at 95% of video length is 15.51%. At level 1 of students' interaction, students have reaction feature to the animation learning media total at 55.17%. At level 2 of students' interaction is online discussion post which divide into different categories. It was found that the most online discussion post is asking question category, giving reason category and agreeing category at total post at 24.13%, 18.96% and 13.79% respectively. The finding could provide new insights for the development of online learning and adjusting the learning process to study the student's online learning behavior and increase students interest and interaction in animation learning media for online learning.**

Keywords*— *animation; digital media; online learning; social network

I. INTRODUCTION

As the social media technology continues to advance, social network sites have become famous in our society. For last decade from media and wide use of computer-supported technologies have been combined in social media usage with the recent data on Facebook [1]. Facebook is one of the most popular social networking. Also, in Thailand, Facebook is still the top 3 social platforms. The trend of social community has also changed the learning environment. Social media becomes one of the most learning tools. The role of social media in education is the effectiveness of social media as a learning tool with the use of technology in the course. Popular social media among secondary school students is Facebook, one of the social networking services, which is widely used. In 2014, Facebook has become a significant part of daily life for more than 2 billion users across the world. Facebook's large and diverse sets of data could be used to overcome the limitation of learning environment by providing access to record behaviors expressed. Nowadays, learning has been transformed into more social, open and collaborative learning experiences. With this tool of educational innovation, lecturers will need to know and learn how to use social media in their courses to help the students learn more and achieve learning objectives [2]. Students with different characteristics and backgrounds interact with others for educational purposes, especially on social network. In addition, to enable better organization of course, time saving and flexibility of location, the main advantage of digital technology is to facilitate cooperation and communication [3]. Facebook could make accessible and communicative between lecturers and students to continue their interactions. Also, empowers them to have interactions with online learning materials and their classmates. One purpose of social networks such as Facebook is that they promote learning in society. Lecturer and students can establish multiple links with other, exchanging opinions, sharing information and knowledge, analyzing content etc. [4]. From the limitation of face-to-face learning, online learning on social media, Facebook has less intrusive ways of gathering the students' data. Some studies have devoted effort to conduct statistical analysis of structed data, such as students' clicks, video browsing and assignment submission. Besides, it is interesting to implement the technology from Facebook to get information related to the student's interaction on Facebook.

The use of animation as instructional learning tools could have more cognitive and emotional impacts for students. This learning media is directly attracting the students by moving images. Moreover, animation learning media also prevent students from getting bored and attract students' attention with more effective teaching technique than traditional lectures. So, animation becomes more crucial than ever for communication. Using technology of animation to create the illusion of motion and usually combined with audio for use in multimedia projects for various purposes, such as a material for learning [5].

The emergence and development of communication such as smartphones, e-mail and internet provide more channels for social interaction.

Social interaction is a basic function of social media. Most popular social media have diverse function and goals with different interaction mode. Social interaction not only stimulate the user's relationship but also provide users access to a variety of instrumental or emotional support for users. With the use of Facebook as a learning platform and the animation learning media posted on Facebook. In this research, we analyze the level of students' interaction. Proposing an approach to collect and analyze the students' revisiting, reaction feature and discussion post. This research could provide new insights for the development of online learning and adjusting the learning process to study the student's online learning behavior and increase students' interest and interaction with online learning. Finally, the results from this form of online learning could help lecturers enhance their teaching and learning practice in the future.

II. MATERIAL AND METHODS

A. Role of user's interaction in social media

The role of user's interaction in social media is to classify user roles considering community users' structural positions. The study of interaction referred to the audience in relation to media content. In conclusion, there are 3 types of user roles which are divided into 3 levels from 0 to 2. Level 0 is students who watch the animation learning media. Level 1 is students who have interaction feature in one way. Level 2 is students who have online discussion with other classmates.

B. Participants

Participants are 58 secondary school students enrolled in physics subject. The inclusion criteria for the sample is that they enroll in secondary school education and have their own smartphones and Facebook accounts, also, they should be familiar with how to use Facebook.

C. Design and procedure

To provide online learning, we use Facebook with animation learning media as a supplement. At the beginning, the lecturer posts the animation learning video and encourages the students to participate. According to the research scenario, the details are as follows: 1) using Facebook as a learning platform to build a course and all students are asked to join the Facebook page member of this course. 2) The lecturer posts an animation learning media on Facebook and assigns to students for learning. 3) During the course, students can have interaction with the animation learning media and with their classmates. 4) Collects the data from the students' interaction.

D. Design and development of animation learning media

The animation as learning media is work and energy topic. This topic is one of the learning outcomes in physics for secondary school students from indicators of science learning subject in 2017. In this course, we create animation learning media on work and an energy topic with total time of 10 minutes based on animation production pipeline. In the first half of the animation is the theory and at the second half is usually the exercise example. The 5-scale Likert questionnaire is used to assess the quality of the animation learning media. We develop the 20 items in language, image, presentation and facilitation and video display aspects for media experts. Figure 3 shows the created animation learning media. It is found that the results of the assessment of media experts has an average score of 4.47. This score shows that the initial media product is well developed and ready to use. The summary of values in each expert field is then combined and has a score of 4.60. The score shows the conclusion that the animation learning media gets a good and feasible category to proceed to the next product trial.

Fig. 1. Animation video learning media, describing work and energy topics and test examples

E. Data source and data analysis

The data collection and analysis process are described into 2 parts. For the first part, the Facebook insights statistic report provides video metric data on the number of video revisiting log data. Then, the spreadsheets file downloaded from Facebook represent the information about the animation video post. Also, the script is created to query the important data. Therefore, we examine 4 indicators of students' animation learning video revisiting log data: the number of times video is viewed more than 3 seconds, the number of times video is viewed more than 60 seconds and the number of times video is viewed to 95% of its length. For the second part, we collect the students' reaction and online discussion post on Facebook from the graph API explorer in form of text. Then, segment the text to be classified into categories. After that, the data are visualized. The overall data collecting is shown in Figure 2.

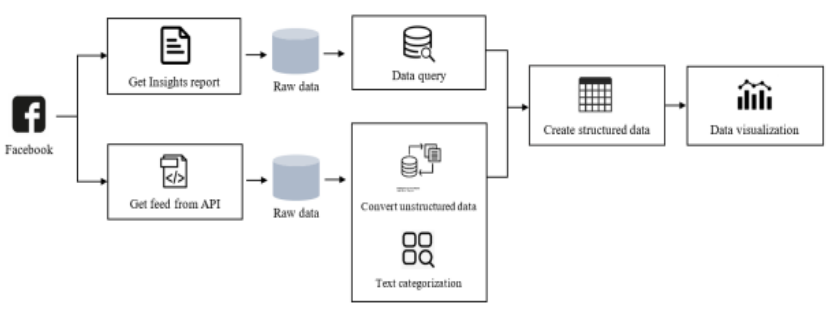

Fig. 2. Data collecting and analyzing method

III. FINDINGS

A. *Student's revisiting of animation learning media*

For student's revisiting of animation learning media represent interaction level 0. Students are able to watch the animation learning media as frequently as they want. This number is an indicator of how engaging the content is. In the first week, students all received the animation learning video posted on Facebook. The video learning media can be viewed at any time. It is found that the total number of students revisiting in 3 seconds, 30 seconds, 60 seconds, and more than 95% of video length are 34 (58.62%), 26 (44.82%), 18 (31.03%) and 9 (15.51%) respectively. Near the end of the week, the number of students revisiting rate of the video has increased considerably. Figure 3 shows the total number of students' revisiting.

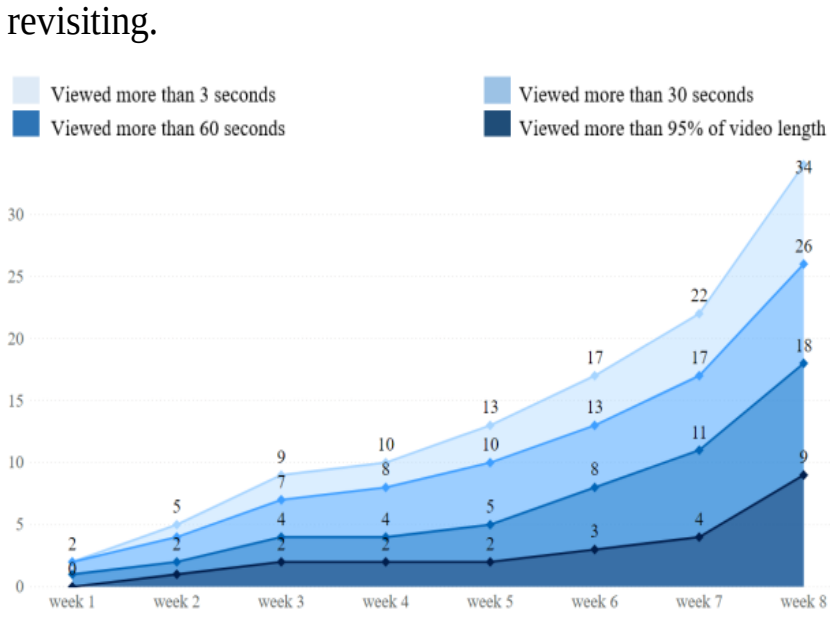

Fig. 3. Total number of students' revisiting

The increased number of students revisiting between each week represents that the maximum increased amount is at week 7 to week 8. At the end of the week of the course, students will come back and review the animation learning media that is watched more than 95% of video length has increased by 5 persons. However, the amounts of revisiting in 3 seconds, 30 seconds and 60 seconds do not increase much between week 1 to week 6, which could be seen that the number increases randomly.

B. *Student's reaction feature on Facebook*

The student's reaction represents the level of interaction level 1. The reaction feature consists of 6 reaction features referencing from Facebook. In figure 4 show the number of students' reaction. The total reaction from students is 32 reactions (55.17%). Most students express their positive feeling rather than negative. It is found that 'Like' is the most reaction which is at the total of 14 reactions (24.13%), followed by 'Wow' reaction at total 6 reactions (10.34%). 'Sad' reaction is the third reaction which is negative feeling at a total of 5 reactions (8.62%). The angry reaction got the lowest number of reactions at 0 reaction. Moreover, all the reactions tend to increase in week 6 to week 8. The reaction can be divided into positive feeling and negative feeling. When compared between positive and negative feeling reaction, it is found that 81.00% are positive reactions and 19.00% are negative reactions.

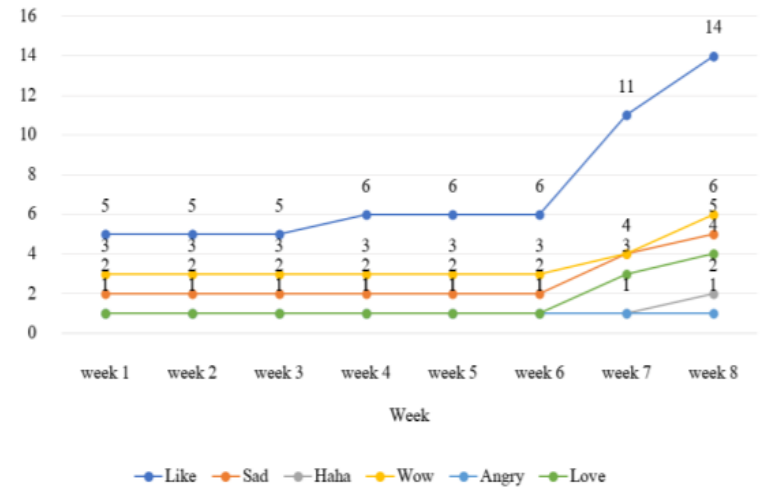

Fig. 4. Number of students' reaction type by week

C. *Students' online discussion post*

ICAP framework proposes a hierarchical framework to classify types of students learning behaviors [6], according to distinguishing cognitive features: interactive, constructive, active and passive. This principle could be applied to categorize the students' online discussion on Facebook as well. The text categories, definitions, and keywords are as the follows: non-contribution, agree, disagree, give reason, request justification and ask questions, build on, share, compare, make a claim and answer [7].

For students' interaction level 2 which is online discussion post. The number of posting activities reflects the students' engagement of the animation learning media posted by lecturer. We classify the students post based on 10 categories. Different categories indicate the differences of idea and details. Figure 8 shows the number of each discussion categories. It is found that most posting categories are request justification and ask questions with number of total posts at 14 posts (24.13%). The number of all categories post depend on the question asked. Questions and answers that have been asked and answered will not be asked again. Followed by the given reason category with the number of totals at 11 post (18.96%). The third category is agreeing category with the number at 8 posts (13.79%). Agreeing category comes from when students agree with the answers from their classmates in the post. The lowest post category is built, compared and makes a claim with number of total posts at 4, 3 and 2 posts respectively. The total answer category is 44 posts which comes from all of the categories. Also, it could be seen that the maximum increase of posts is in the last two weeks. While the first week of leaning there are no Q&A about the course content, only greetings. Most of the posts are positive post, supporting each other's ideas and explaining reasons.

IV. DISCUSSION

For the students' interaction level 0, the students' video revisiting at 95% of video length is the good rate for learning. For the number of students who watch animation more than one time is 15.51% and happens between the last week of the course. In the last week before the course ends, the number of

revisiting rates has the maximum increase. Since before the final exam, students will review the content of the course again and early review is not a popular behavior of the students. Examining the animation with the most revisiting views informs what video content to be shared and produced for students, and how to get more students to watch until the end of the animation. Nevertheless, animation learning media could get students to attain greater understanding [8] but could not get the number of students' revisiting as expect. For the students' interaction level 1, we found that student's reaction is 'like' feature which is the common reaction. Most students have positive reaction more than negative reaction. However, the number of likes is not related to animation viewing number. Students may press like, but may not watch the animation learning media. For the students' interaction level 2, the key to be effective on this Facebook online learning is that students must interact with their classmates. Most students interact with other students during the course which is an important part of their learning experience [9]. We find that requesting justification and asking questions, agreeing and giving reasons are the top categories that students post, respectively. Posts containing these categories are more likely to be received a response than other post categories, which may boost students' interaction. Different categories of students' online discussion post come from different motivations and curiosity. In addition, adding new format of posting could make students more likely to engage with posts [10], such as hash tags or mentions. However, some idea units do not clearly fit in any categories in this classification.

V. CONCLUSION

In conclusion, at level 0 of interaction re-watching the animation learning media, the students will observe and learn with interest in the learning content but showing no retaliation or have any interaction with others. At level 1 of interaction, it is considered as a one-way communication that students could express their feeling. Clicking on reaction feature buttons is to show how students feel about seeing this learning media post. At level 2 of interaction, it is shown that students have two-way communication with their classmates. Having a Q&A shows their interest in learning and when there is a question, they will have interactions with classmate with different post categories. Moreover, online discussion could encourage their classmate to be interested in the learning content and other discussions will follow. Therefore, providing online discussion post is important to advance knowledge construction [7]. This study highlights that the use information technology from social media could be advantage for learning. Secondary schools could use Facebook data to develop and provide the analytics and reports so that students, lecturers and institutions could make learning course more effectively [11]. In order to understand the findings more, it is important to collect more samples and understand the students' lifestyles and habits.

For future research, more social network sites and more social interactions within or across platforms should be utilized to improve online learning. Additional discussion tools that allow students to post and participate and the homophily pattern analysis should be applied to find the relationship among the students [9]. Also, the duration for the research should take longer and sample should be taken from more than one institution to reach accuracy of the results. However, explaining the relationship of level of interaction and students' learning achievement should be studied as well.

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P02353

Mobile Learning Application Applied for Enhancing Employee's Surveillance Prevention and Control of COVID-19 in Electronics Industry

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Abstract

The COVID-19 epidemic has rapidly spread in the electronics industry, resulting in a lack of labor in the production of products for export. Because employees were infected with COVID-19 and had to stop being detained according to government policies. Reasons for the rapid spread are born from employees' not having a proper understanding of the care and protecting themselves from COVID-19. Therefore, it is necessary to develop a training model in accordance with the current situation to increase the understanding of COVID-19 for employees. In this paper, we propose a training style through the application of mobile learning, accompanying the illustrated cartoons, to strengthen the surveillance, prevention, and control behaviors of COVID-19 among employees in the electronics industry. The samples in this study were five hundred and twelve employees in the electronics industry, factory 8. We have developed a mobile learning training model where employees scan QR-CODE and register for training. Assessment and measurement of learning achievement before training and after training of employees in the electronics industry, employee

behavior observation records and assesses satisfaction with the training style through the application of mobile learning, accompanying the illustrated cartoons, to strengthen the surveillance, prevention, and control behaviors of COVID-19 among employees in the electronics industry. An academic achievement after learning of employees is higher than an academic achievement before training. Statistically significant at the 0.01 level. After training, employees have behaviors of surveillance, prevention, and control of COVID-19 in the electronics industry than before training. Statistically significant at the 0.05 level. The employees who are trained by the application of mobile learning, accompanying the illustrated cartoons, are very satisfied.

Keywords– Surveillance Prevention and Control COVID-19, Mobile Learning

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Mobile Learning Application Applied for Enhancing Employee's Surveillance Prevention and Control of COVID-19 in Electronics Industry

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***Abstract*—The COVID-19 epidemic has rapidly spread in the electronics industry, resulting in a lack of labor in the production of products for export. Because employees were infected with COVID-19 and had to stop being detained according to government policies. Reasons for the rapid spread are born from employees' not having a proper understanding of the care and protecting themselves from COVID-19. Therefore, it is necessary to develop a training model in accordance with the current situation to increase the understanding of COVID-19 for employees. In this paper, we propose a training style through the application of mobile learning, accompanying the illustrated cartoons, to strengthen the surveillance, prevention, and control behaviors of COVID-19 among employees in the electronics industry. The samples in this study were five hundred and twelve employees in the electronics industry, factory 8. we have developed a mobile learning training model where employees scan QR-CODE and register for training. assessment and measurement of learning achievement before training and after training of employees in the electronics industry, employee behavior observation records and assesses satisfaction with the training style through the application of mobile learning, accompanying the illustrated cartoons, to strengthen the surveillance, prevention, and control behaviors of COVID-19 among employees in the electronics industry. An academic achievement after learning of employees is higher than an academic achievement before training. Statistically significant at the 0.01 level. After training, employees have behaviors of surveillance, prevention, and control of COVID-19 in the electronics industry than before training. Statistically significant at the 0.05 level. The employees who are trained by the application of mobile learning, accompanying the illustrated cartoons, are very satisfied.**

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I. INTRODUCTION (*HEADING 1*)

In December 2020, Thailand found an outbreak in the second wave of COVID-19. As a result, the electronics industry has been affected by this wave of outbreaks [1]. As the government has advised measures to require residents to work and live at home and avoid unnecessary contact with the outside world [2]. But of course, work from home (WFH) cannot be used in every position, especially in the manufacturing industry. As a result, the electronics industry is exempt from work from home (WFH). The employees still have to work in the industry as before. This is why there is a cluster in the electronics industry and the spread of infection is quick. This may be due to non-compliance with infection control measures. Adherence to infection control measures is potentially influenced by people's knowledge, attitudes, and practices about the infection. It is possible that employees in the electronics industry may not have a thorough understanding of COVID-19.

To assist in increasing knowledge and understanding about surveillance, prevention, and control of COVID-19 among employees in the electronics industry, urgent measures were needed to evaluate the employee's knowledge about the infection at this difficult time. Therefore, The aims of this study were to develop a training model through mobile learning with illustrated cartoons to enhance employees' surveillance, prevention, and control of COVID-19 in the electronics industry, to study the training achievement of employees using mobile learning and to evaluate the general satisfaction with the mobile learning training model with illustrated cartoons. The findings of this study are expected to help reduce the spread of COVID-19 in the electronics industry and increase employee cognition to strengthen behavior surveillance prevention and control of COVID-19 in the electronics industry.

II. RELATED WORK

A. Factory contexts affecting the spread of COVID-19

The electronics industry has an environment that is an air-conditioned room that must keep the machinery cool all the time. Making it easier to spread the virus because the COVID-19 virus can live on objects and appliances at 20 degrees Celsius for 4-5 days [3]. However, the electronic industry is a detailed work that requires many employees to work. making the working area dense, causing an epidemic in the production line quickly. According to data collection studies, employees are not aware of the protection

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taking care of themselves from the COVID-19 virus, Some employees also took off their masks while talking to their coworkers, leading to constant infections in the factory. COVID-19 is spread through respiratory inlet and secretion contact, which can be infected by touching the ears, eyes, nose, and mouth. This makes it easier to spread.

The electronics industry has followed the policy guidelines of the Ministry of Public Health and provincial departments. Employees are required to wear masks at all times while working, wash their hands regularly with soap or alcohol, and provide vaccines to vaccinate all employees. However, some employees do not have knowledge of COVID-19 or are misinformed about COVID-19, making them unaware of how to protect themselves. As a result, the behavior is at risk of contracting COVID-19. Therefore, it is necessary to organize training to educate employees about COVID-19. to make employees aware and reduce the spread of germs in the production line. Nareemah, Kantamaht, and Kalaya have studied research on prevention behaviors of coronavirus disease 2019 of students [4], They found that students with a good level of COVID-19 knowledge had a high level of protective behavior against COVID-19. Therefore, effective COVID-19 prevention behaviors require incident clarification and serious education.

B. Mobile Learning and illustrated cartoons

Due to the epidemic of the COVID-19 virus, face to face interaction training is not possible to reduce swarming or gatherings. Combined with modern technology, online training is organized as a mobile learning training. Nowadays, mobile phones are one of the most important things for human beings for communication and entertainment purposes. Therefore, using the phone is a benefit in training, but training through learning on a mobile phone must be supported by the Internet network service. Joko Joko, Agusbudi, Supari, and Rina have studied about Effectiveness of mobile learning implementation in increasing student competence and preventing the spread and impact of COVID-19 [5], The results showed that mobile learning can help students understand the content and can prevent the spread of COVID-19. Mobile learning is effective in developing students' abilities.

Guidelines for providing knowledge content to employees of working age need to be motivated to train and attract employees to attend the training. Wanlop has developed Stop Motion animated video materials to promote morality, ethics, and discipline for students [6] to be used as a guideline for solving problems and improving and developing teaching and learning activities. The results showed that video teaching, as embodied in stop motion cartoon teaching, had higher post-study achievement than before the class and had higher moral and ethical behavior after studying. But in the context of the electronics industry, By using a tool called "Google Form," the research conceptual framework is shown in Fig. 1.

III. IMPLEMENTATION

This research is a quantitative and qualitative research, which provides training to educate employees about COVID-19 through mobile learning, accompanying the illustrated cartoons by analyzing data using descriptive statistics, mean, standard deviation, and t-test.

This research has a research period of 9 months. The study was conducted from April, 2021 to December, 2021. Cal-comp electronics (Thailand) public co. Ltd. was an implemented site. The electronics factory has a total population of 4,321 people. The sample consisted of no.8 factory employees by purposive sampling method of 512 people. The sample employees are all working in the same industry, and it was the first group to find clusters in the electronics industry. Therefore suitable for this research to help reduce the rate of spread of the COVID-19 virus.

The tools used to collect data are knowledge tests and questionnaires. The pre-and post-training knowledge tests consisted of the same set of 10 questions, which were multiple-choice questions with 4 options. The questionnaire consisted of 2 parts: the self-protection behavior questionnaire from COVID-19 and the satisfaction questionnaire on using mobile learning in training. The self-prevention behavior questionnaire for COVID-19 is a three-level multiple-choice test consisting of never, sometimes, and always, while the satisfaction questionnaire had five levels: low, minimal, medium, high, and most. The qualitative data collection tool was observational.

IV. RESULT AND DISCUSSION

Fig. 2. shows a mobile learning platform page using a tool called "Google forms", used for training industrial workers on the surveillance, prevention, and control of COVID-19 in the electronics industry. by having employees scan QR-CODE to register before attending the training, After that, take a pre-training test to measure the level of knowledge about COVID-19, next, it will provide informational content about COVID-19 through lectures in the form of illustrated cartoons and post-training tests to measure knowledge before and after training.

Table I shows the learning achievement before training and after training through mobile learning includes illustrated cartoons to enhancing employee's surveillance, prevention, and control of COVID-19 in the electronics industry. An academic achievement after learning of employees is higher than an academic achievement before training. Statistically significant at the 0.01 level. Which is based on assumptions.

Table II shows assess the behaviors of surveillance, prevention, and control of COVID-19 among employees in the electronics industry.

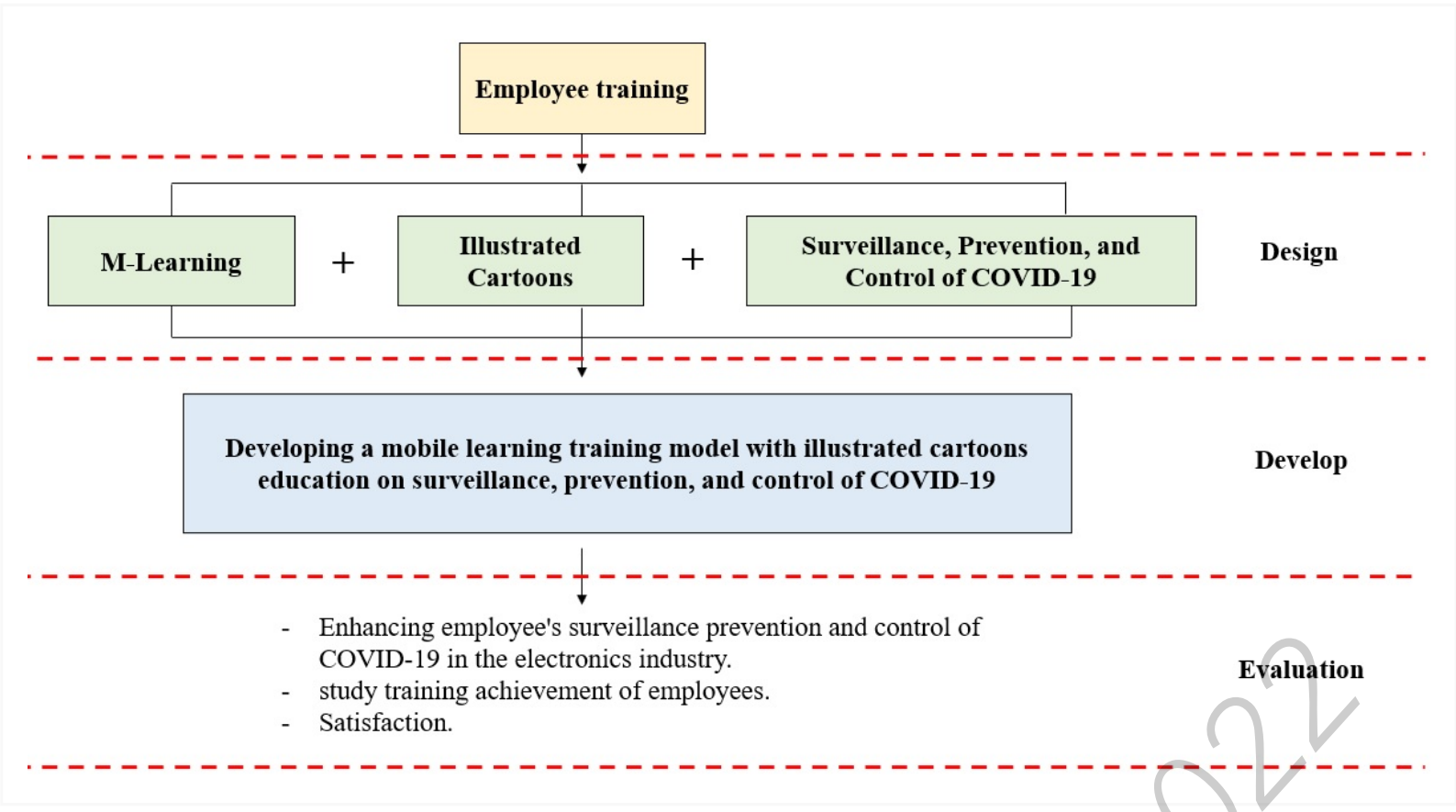

Fig. 1. Conceptual framework.

According to the observation record behavior of surveillance, prevention, and control of COVID-19 through mobile learning training, which includes illustrated cartoons to enhance employee's surveillance, prevention, and control of COVID-19 in the electronics industry before and after training, for 512 employees in the no.8 factory.

From the table II, it was found that the evaluation results behavior employee's surveillance, prevention, and control of COVID-19 in the electronics industry after training through mobile learning coupled with illustrated cartoons were significantly higher than pre-trained at the 0.05 level, according to the hypothesis. from the assessment table, The mean is obtained by taking the total score obtained from the behavior assessment observation form and dividing it by the number of sections. so we get the average.

Fig. 2. Google form platform page

The outcomes of self-protection behavior from the COVID-19 virus of sample employees after the training showed that the employees' self-defense behaviors were slightly higher than before. Data were collected through self-assessment questionnaires. Employees are already following the COVID-19 prevention guidelines as per the Ministry of Public Health until employees gain more knowledge and understanding of COVID-19 to strengthen employees' awareness of self-protection.

In the case of infected people, after training using Mobile Learning, no epidemic was found in the production line of the sample for 5 months.

The results of the analysis of satisfaction with the use of mobile learning for surveillance, prevention, and control of the COVID-19 virus. Overall, employees' satisfaction with mobile learning was high in all aspects. Employees had the highest overall satisfaction and the least satisfaction with the topic. The result of this research was that the employee wanted to add more content to the comics section.

TABLE I. LEARNING ACHIEVEMENT BEFORE TRAINING AND AFTER TRAINING THROUGH MOBILE LEARNING INCLUDES ILLUSTRATED CARTOONS TO ENHANCING EMPLOYEE'S SURVEILLANCE, PREVENTION, AND CONTRO OF COVID-19 IN THE ELECTRONIC INDUSTRY

Test	Number	Mean	S.D.	t	Sig.
Before	512	5.19	40.18	40.18	0.01
After	512	8.99	0.83		

TABLE II. SATISFACTION WITH USING MOBILE LEARNING TO ENGAGE IN KNOWLEDGE THROUGH ILLUSTRATED CARTOONS

Test	Number	Mean	S.D.	t
Before	512	2.04	0.20	15.62
After	512	2.59	0.17	

This research shows that employee learning achievement after mobile learning training coupled with illustrated cartoons to enhance the surveillance, prevention, and control behaviors of employees in the electronics industry is higher than before training, statistically significant at the 0.01 level. As mobile learning training is coupled with illustrated cartoons, activities are designed to help motivate and inspire employees. The content is organized into illustrated cartoons so that employees are interested in and follow the story of the characters and are interested in the content being trained. As a result, mobile learning training was higher than before.

After training, employees' surveillance, prevention, and control behaviors for COVID-19 in the electronics industry. higher than before training, statistically significant at the .05 level. After training, employees' surveillance, prevention, and control behaviors for COVID-19 in the electronics industry. higher than before training, statistically significant at the 0.05 level. Because of its unique, easy-to-understand, and content related to daily life, it is easy to understand and relevant to employees' daily lives and can actually reduce the spread of COVID-19 in the electronics industry.

Employee satisfaction with mobile learning training was at a high level. Because this kind of training is time-saving, easy-to-understand, content that is engaging, easy to understand, and attractive, it makes it easy to understand.

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P02327

Problem-based learning using a demonstration of sensor system

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Abstract

Developing students' thought processes is more important than memorization. Problem-based learning is one of the developments in this thought process. Problems in the field of science and engineering can be solved in a various solution. For example, using variety of sensor type devices which recognize various physical quantities such as sound, light, heat, force, etc., and process them with an embedded system. The result of processing can lead to something like record values to store as statistical data or control electrical equipment. This paper presents the design and construction of a demonstration kit of various sensors in embedded systems. To focus on using, students learn the working principle of various sensors and transducers. It can be used with simple embedded system. Finally, the problem is set, so that students can apply the knowledge for their solutions and present them as a group work.

Keywords— problem-based learning, sensor system

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Problem-based learning using a demonstration of sensor system

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***Abstract*—Developing students' thought processes is more important than memorization. Problem-based learning is one of the developments in this thought process. Problems in the field of science and engineering can be solved in a various solution. For example, using variety of sensor type devices which recognize various physical quantities such as sound, light, heat, force, etc., and process them with an embedded system. The result of processing can lead to something like record values to store as statistical data or control electrical equipment. This paper presents the design and construction of a demonstration kit of various sensors in embedded systems. To focus on using, students learn the working principle of various sensors and transducers. It can be used with simple embedded system. Finally, the problem is set, so that students can apply the knowledge for their solutions and present them as a group work.**

Keywords—problem-based learning, sensor system

I. INTRODUCTION

Nowadays, most of electrical devices are used in daily life. Manufacturers try to design their product to be smarter because of the adoption of embedded systems used in various forms which adds value and convenience to consumers. Learning the technology of embedded systems is therefore important for people who are interested in various levels such as students, researchers, engineers, and others [1]-[2]. It is absolutely necessary for implementing embedded systems with sensors and transducers to perceive physical quantities such as sound, light, heat, force, etc. Due to advances in semiconductor manufacturing technology, more type of sensors and transducers are being used with lower price and more accurate measured data. It is therefore a first priority to learn how sensors and transducers work which to know the scope and limitation of usage in the appropriated environment. In this paper, the concept of designing and building a demonstration kit for standard sensors and transducers is presented for learners to practice thinking skills and to analyze the problem before applying these skills to engineering project courses and others. This research is to develop learning outcomes in an analytical ability and problem solving with appropriate methods including the application of appropriate tools [3]-[5]. It is suitable for undergraduate student in the Sensors and Transducers course in Department of Electrical Engineering Faculty of Engineering and Industrial Technology, Silpakorn University.

II. DESIGN OF SENSOR APPLICATION SYSTEM

A. System Design Specification

With only one semester of learning time, choosing a microcontroller is important in terms of how difficult it is to understand for programming a whole system that reads from various sensors. Therefore, the Arduino Pro Mini is chose as an 8-bits microcontroller that can develop in C programming language, which is popular for making an embedded system. This sensor system composes the following 4 types of sensors such as,

- LDR (Light Dependent Resistor) is a light-dependent resistor. This type of resistor can change its conductivity non-linear proportional to the intensity of incident light.
- NTC (Negative Temperature Coefficient) thermistor is a temperature- dependent resistor. Its resistance is non-linear inversely proportional to the temperature.
- FSR (Force Sensing Resistor) is a resistive pressure sensor. It was developed with polymer thick film technology. This pressure detector provides a lower resistance as more pressure is applied to the sensing film. The FSR is not a load cell or strain gauge, but has a similar function. It can detect pressure, but the FSR provides a trending value.
- Ultrasonic range finder module is a sensor module for object detection and non-contact distance measurement using ultrasonic operating frequency 40 kHz.

Circuit schematic diagram of sensor system was shown as Fig. 1. It consists of a 16x2 character LCD with backlight, 8 dual color LEDs, buzzer for sound generator, and 2 SPST switches for selecting menu. This system was operated from 5Vdc power supply which composes of a 3,000 mAh Li-Ion battery, charging module and DC-DC converter circuit for generating 5Vdc.

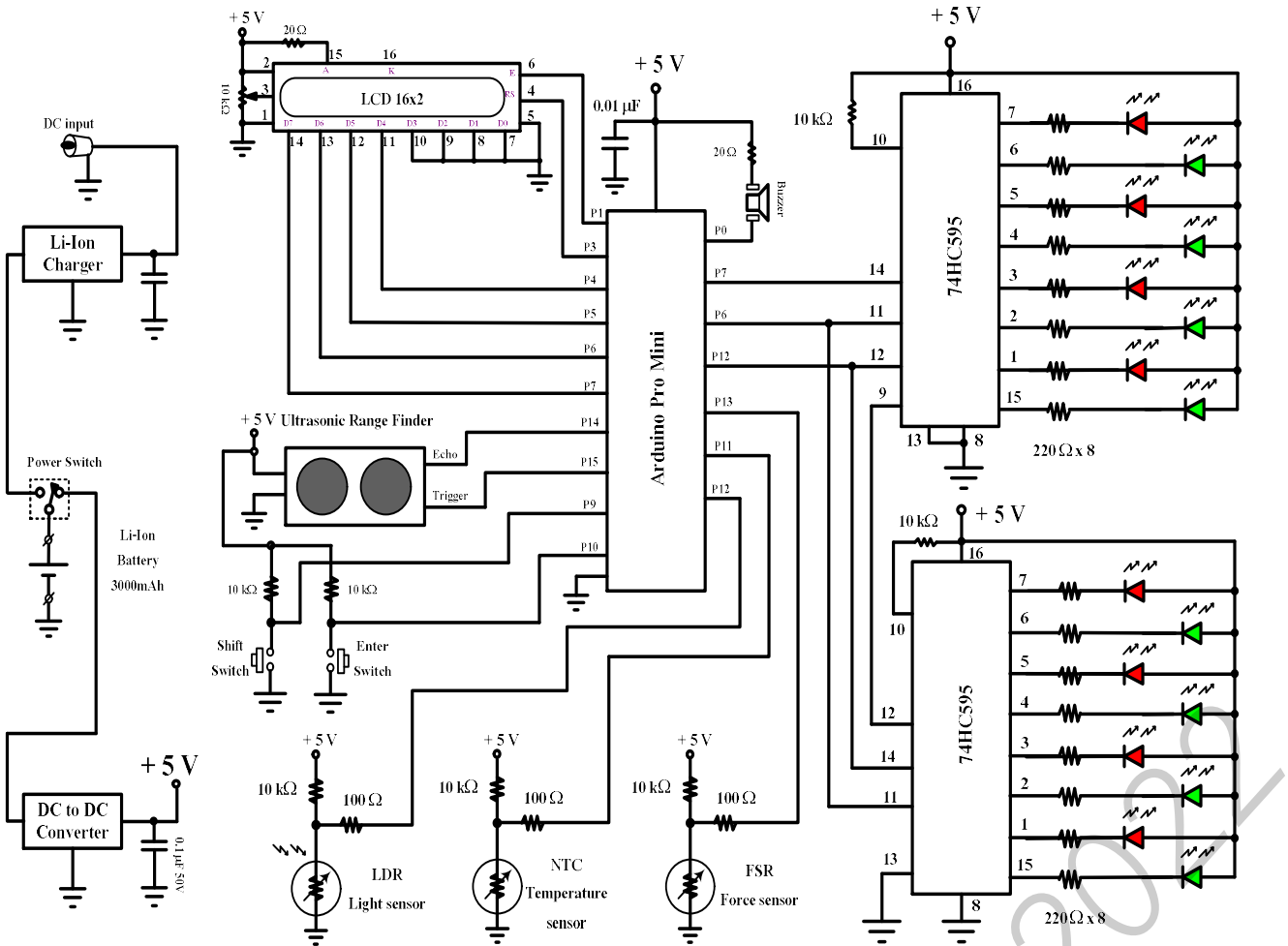
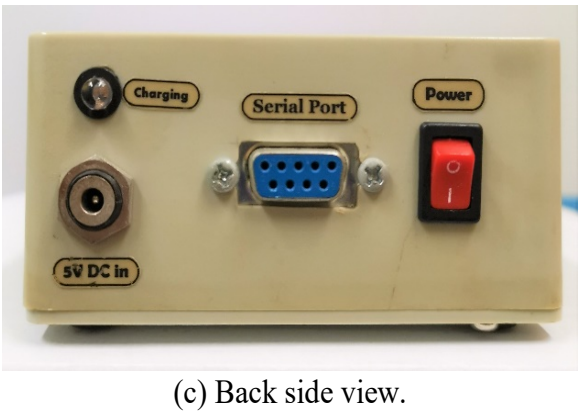


Fig. 1. Circuit schematic diagram of sensor system.

(a) Top view.

(b) Front side view.



(c) Back side view.

Fig. 2. Sensor system box and its lay out.

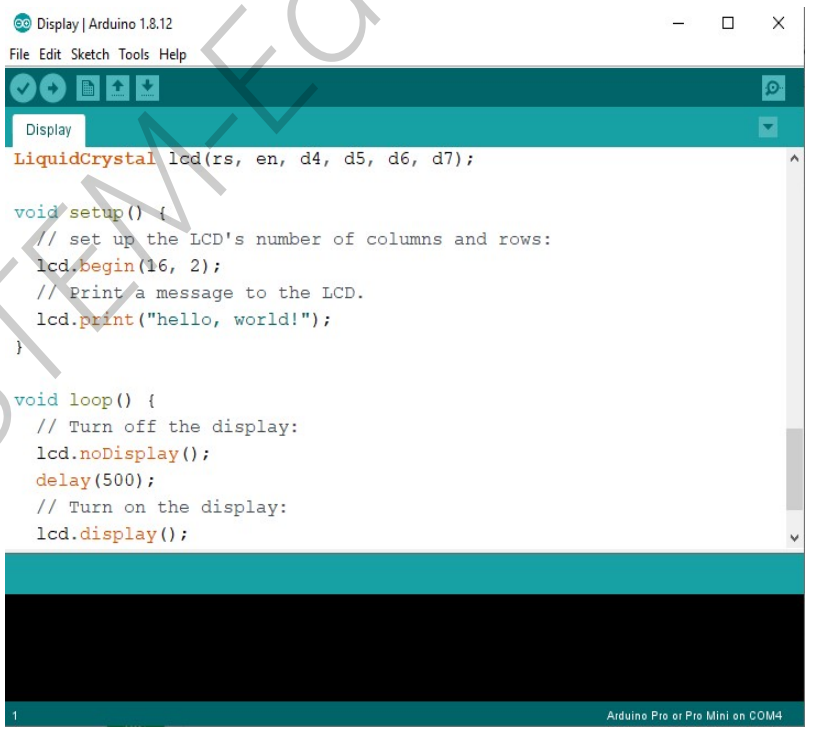


Fig. 3. The Arduino IDE program.

From the specifications that require a microcontroller-based experimental system that is not too complicated. Compact box style and size which can be applied to the project. Therefore, it is the origin of the design and construction of the experimental box itself, as shown in Fig. 2, showing its lay out. The sensor system is designed for C programming using the Arduino IDE, as shown in Fig. 3, which is free ware. Other related sample libraries and example codes can also be downloaded free of charge via the various web sites.

B. The experimental topics for the sensor application system

In the course of sensors and transducers, it is focusing on students to learn the working principles of various types of sensors and transducers. The experimental set, the standard sensors and transducers are focused on the measurement of physical quantities as follows,

- Light intensity measurement via LDR : Students will not know the circuit schematic diagram of the system, but will only know when the incident light intensity of the LDR changes, causing the voltage to change. (Displayed on the LCD screen of the sensor system box). Each student group finds information and analyzes how the internal circuits is connected. The sensor system box is used to create an experimental model for finding the specifications of the sensors connected to the system. For example, design an experiment to find a light source that can adjust the given light intensity, illuminates on the LDR at an appropriate distance. Then the measured voltage is collected from the internal circuit which is displayed on the LCD screen to graph the relationship between the incident light intensity and the measured voltage. Then use its data to write a program code to show the light intensity value to be displayed on the LCD screen when there is light incident on the LDR next time. After that, collect the information to present to classmates. While discussing the ideas and problems that ultimately arise.

- Temperature measurement via NCT thermistor : Students will not know the circuit schematic diagram of the system, but will only know when the temperature of the NCT thermistor changes, causing the voltage to change. (Displayed on the LCD screen of the sensor system box). Each student group finds information and analyzes how the internal circuits is connected. The sensor system box is used to create an experimental model for finding the specifications of the sensors connected to the system. By designing an experiment to find a source that can adjust the temperature, contact to the NCT thermistor and record the measured voltage from the internal circuit. which is displayed on the LCD screen to graph the relationship between the temperature value of the NCT thermistor and the measured voltage. Then use its data to write a program code to show the temperature value of the NCT thermistor to be displayed on the LCD screen next time. After collecting the data for presentation to classmates. While discussing the ideas and problems that ultimately arise.

- Pressure measurement via FSR : Students will not know the circuit schematic diagram of the system, but will only know that when the FSR is pressed, the voltage will change. (Displayed on the LCD screen of the sensor system box). Each student group finds information and analyzes how the internal circuits are connected. The sensor system box was used to create an experimental model for finding the specifications of the sensors connected to the system. By designing an experiment to find the weight of the given object of an appropriate size, place it on the FSR and record the measured voltage from the internal circuit which is displayed on the LCD screen to graph the relationship between the weight and the measured voltage. Then use its data to write a program code to show the dual color LED scoring in relation to the next pressure measurement. After that, collect the information to present to classmates. While discussing the ideas and problems that ultimately arise.

- Distance measurement via Ultrasonic range finder : Students will learn the circuit schematic diagram of the system and know the values shown on the LCD screen (not the actual distance) which vary according to the obstacle position in front of the sensor system box. Each student group writes a program code to show the actual distance value (centimeter or inch unit) on the LCD screen for the next measurement. Each student group designs an experiment to test the reflection of sound waves on objects of various sizes how it affects the accuracy of the measurement then take the information obtained. After that, collect the information to present to classmates. While discussing the ideas and problems that ultimately arise.

III. System Evaluation

The sensor system box demonstrates the use of various sensors in an embedded system for teaching in the sensors and transducers course with 59 students. The evaluated results of student satisfaction are done by the end of semester as shown in Tab.1 [6]-[7]. Most of students satisfied in this course with score over 4. However, the last topic about devices and equipment has score lower than 4. Due to the COVID-19 situation at the end of the academic year 2019, the experimental model has changed to demonstration of the sensor system box working, instead of dividing groups of students to find information design additional experiments. However, from the demonstration, the students were able to think and analyze the usage patterns of standard sensors and transducers to some extent. As shown in Fig. 4 and Fig. 5, learning outcomes were assessed by senior engineering students in the Department of Electronics and Computer Systems and displayed in TQF5, which enabled students to have a good understanding of the course content.

TABLE I. Evaluated Results of Student Satisfaction

Topics	Mean	SD
Instruction management	4.32	0.71
Lesson plan	4.27	0.74
Emerging theories and practice	4.32	0.68
Programming skill development	4.37	0.67
Devices and equipment	3.63	1.05

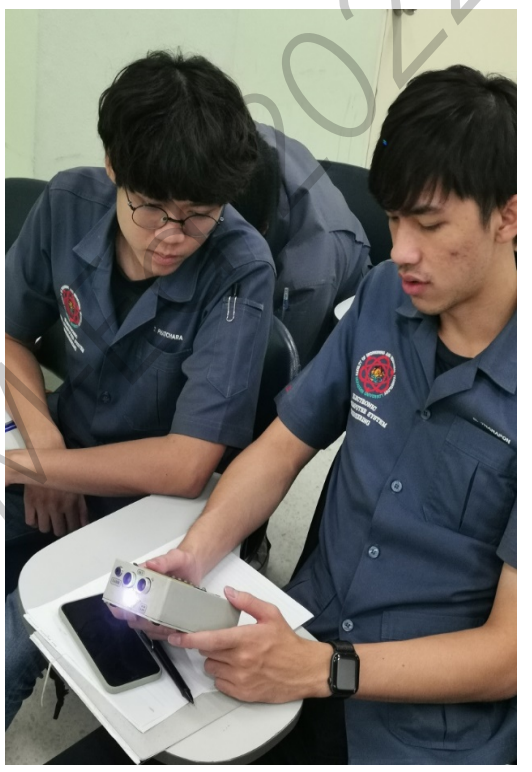
Note : The lowest and highest score of satisfy are 0 and 5, respectively.

(a)

(b)

Fig. 4. Experimental demonstration of .sensor system box

(a)



(b)

Fig. 5. Student trial.

IV. CONCLUSION

This paper presents the design and construction of sensor system box for demonstrating the use of various sensors in embedded systems. It was used in the course of sensors and transducers. The experiments have already been put into practice. The results satisfy the need for problem-based learning which is one of the development of thought processes of learners to have thinking skills, analyze and solve problems from various knowledge leading to endless learning.

ACKNOWLEDGMENT

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P02368

Data Scienceand Deep Learning Across the Alliance: A Personalized Project Activated Modality REU

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Abstract

Research Experiences for Undergraduates (REU) bring challenges while lifting expectations in participants. Our learning model engages hands-on applications on algorithms, datasets, and computer power under the auspices of NSF Florida Georgia Louis B. Stokes Alliance for Minority Participation [FGLSAMP] grant: Developing Researchers through Innovative Virtual Experiences [DRIVE]. The alliance represents institutions at various educational levels and ethnicities (two-year and four-year educational institutions of Hispanic or historically black, or predominantly white). We introduced Data Science and Artificial Intelligence (AI) to advocate for students and mentor minority populations in the era of Machine Learning (ML) and Big Data (BD). We involved an interdisciplinary group of undergraduates [such as Computer Science and Engineering, Information Tech- nology, Biology Pre-Medicine, Software Engineering, Pharmacy, Biology Pre-

Dental, and Mathematical Sciences]. By the end of the program, participants integrated AI, ML, and Deep Learning techniques to provide solutions to their projects-self-chosen at the beginning of the REU. This project activated modality began with such topics as Time Series Analysis of Blockchain-Based Cryptocurrency; Analyzing Advantages and Disadvantages of AI for Breast Cancer Detection in Women; AI Analysis of Autism in three different cities, and others. Participants' survey indicated that this was very important and useful for their careers. They reported significant enhancement of essential cognitive and professional skills and enumerable learned skills such as Python, Skit-learn packages to build ML models and Git Github as version control collaborating systems.

Keywords—REU, Data Science, ML, Collaboration, Interdis-Ciplinary, AI

P02354

Employee Upskill with Electronic Work Instruction Using Problem-Based Training

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Abstract

This paper proposes the development to the skills of quality control employees through training by using problem-based techniques together with electronic work instruction. This is due to the fact that problems with employee work procedures and quality control automation can happen at any time, if employees do not have the correct knowledge to solve problems, it will directly affect production efficiency. Therefore, employees should have problem-solving skills. so that those problems do not happen again or happen less frequently in the production process. Work instruction is a tool to assist employees in resolving difficulties in quality control through appropriate and correct steps. However, if the work instruction is not really useable and there isn't a proper employee training process, employees will be unable to perform their duties efficiently. On the other hand, if employees are trained with appropriate procedures in conjunction with work instruction. As a result, the skill and efficiency of employees will improve. The purpose of this

study was to improve the problem-solving skills of employees through problem-based training with electronic work Instruction. as well as reduce problems that arise in the production process related to quality control. The research measurement and evaluation tools consisted of an assessment of employee satisfaction with training, a problem-solving skills assessment form, and a stop recording system. The statistical values used in the data analysis in the research consisted of frequency, mean, percentage, and standard deviation.

Keywords— SIPOC Model, problem-based, training, work instruction, quality control

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Employee Upskill with Electronic Work Instruction Using Problem-Based Training

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***Abstract*— This paper proposes the development to the skills of quality control employees through training by using problem-based techniques together with electronic work instruction. This is due to the fact that problems with employee work procedures and quality control automation can happen at any time, if employees do not have the correct knowledge to solve problems, it will directly affect production efficiency. Therefore, employees should have problem-solving skills. so that those problems do not happen again or happen less frequently in the production process. Work instruction is a tool to assist employees in resolving difficulties in quality control through appropriate and correct steps. However, if the work instruction is not really useable and there isn't a proper employee training process, employees will be unable to perform their duties efficiently. On the other hand, if employees are trained with appropriate procedures in conjunction with work instruction. As a result, the skill and efficiency of employees will improve. The purpose of this study was to improve the problem-solving skills of employees through problem-based training with electronic work Instruction. as well as reduce problems that arise in the production process related to quality control. The research measurement and evaluation tools consisted of an assessment of employee satisfaction with training, a problem-solving skills assessment form, and a stop recording system. The statistical values used in the data analysis in the research consisted of frequency, mean, percentage, and standard deviation.**

Keywords*— *SIPOC Model, problem-based, training, work instruction, quality control.

I. Introduction

Current technology is constantly developing. As a result, the electronics industry has become more competitive in terms of price and quality. Therefore, organizations must face the rapid changes in the environment to meet the growing demands. In addition, the rapid transformation of this technology makes the electronic industry adopt automation systems to increase production capacity and product quality. Likewise, employees within the organization will need to have more knowledge and understanding as well. Organizations in the electronics industry at present have begun to focus on enhancing the skills of their employees to be more effective in response to the increasing competition in the industry. Employee training must follow the correct and appropriate training process. To provide training that meets the needs and meets the goals of the objectives in the organization. Appropriate training approach is required for employee development to meet industry's need.

Problem-based learning is a learning management strategy that encourages students to practice and solve issues on their own. As a result, students will be able to develop their reasoning and problem-solving skills. In general, some employees may forget the trained knowledge or skill if teacher center technique is used as training method. And employees, usually, cannot applied trained knowledge or skill to solve the occurred problem whenever employees encounter problems that are differ from their training. Various problem can be occurred anytime in the manufacturing process therefore problem solving skill of employee is essential. Therefore, the researcher devised the concept of training in conjunction with work instruction because work instruction is a tool that helps verify work processes and helps solve employee problems when there is a suspicion of that workflow. This study uses the SIPOC model to analyze the work instruction inspection used in the work process of the quality control department. In addition, it is used to improve the details of working documents to be more accurate and easier to understand. Electronics work instruction was also developed to support operation and skill enhancement of employees.

II. Training Concepts in Conjunction with Work Instruction

A. Training concept with problem-based

Training is a method of assisting employees in developing skills so that they can be more effective. On the other hand, if the improper teaching process or teaching content does not meet the work objectives. As a result, job quality, productivity, and efficiency are all affected. The researcher has foreseen the problem-based learning management that assists in developing problem-solving skills for students. As a

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training approach to problem-based training consists of 6 processes as follows [2]:

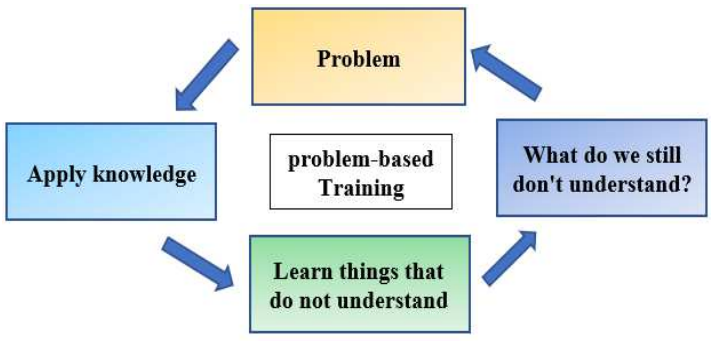


Fig. 1. The sequence of research

problem-solving training It isn't a training process to describe the problem to employees. However, it brings problems as an incentive for employees to see what they don't yet know, prompting them to seek knowledge on their own. After that, the study's findings were used to find solutions to the problems that arose. As a result, employees can have problem-solving skills on their own. It is expressed from the concept of problem-based training as shown in Figure 1.

B. Work processes with the SIPOC model

Suppliers, inputs, process, outputs, customers (SIPOC) analysis is usually used as tool for total quality management [1]. Good work instruction can be obtained by SIPOC analysis, and it is useful for employees to use as a tool for solving occurred problems. Therefore, in order to check and improve the document to suit the working process of the quality control department, SIPOC model was selected to as analysis tool. The SIPOC model's process considers the process's inputs as well as the process's final outcome. It can be divided into five components, as follows [1]:

- Supplier is the person who delivers things or information that must be taken through the process.
- Input is an object or data that must be put through the process.
- Process is a process that consists of several steps to turn input data into output data.
- Output is information that meets the needs of the customer.
- Customer is the one who determines the needs of things or information.

III. METHODOLOGY

The methods of operation in this research can be summarized in 6 major steps as shown in Figure 2. The study's sample group consisted of 9 personnel from the quality control department. which is a quality control staff who is in the same work shift as the researcher

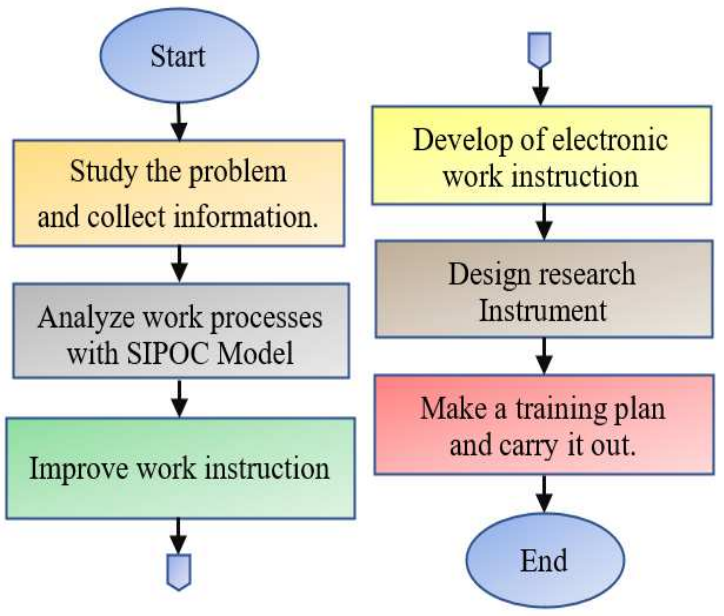


Fig. 2. The sequence of research implementation.

A. Study the problem and collect information.

The researcher studied the data on the production process. and check the statistics of quality control problems in the production process. By analyzing the data from statistics and documents related to the quality control process and then using that data to make a fishbone chart to figure out what might be causing the quality control department to stop production

B. Analyze work processes and improve work instruction

This process was done by researcher under supervise of middle management team. Improvement of the work instruction process is shown in Fig. 3.

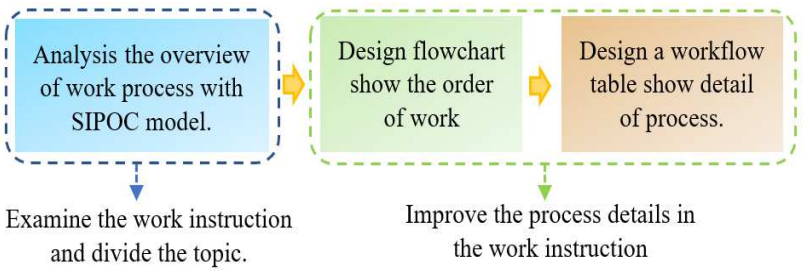


Fig. 3. Overview analysis of the process.

Overview analysis of production process using SIPOC model is shown in table I. It enables researchers to examine and divide the issue of work instruction in order to better improve and develop electronic work instruction.

Improving the process details in the work instruction are just some of the content improvements pertaining to work processes using data from the SIPOC Model analysis. First, select the topic of related work instruction from the SIPOC Model analysis table to create a flowchart showing the sequence of work processes. Next, the designed workflow table shows the details of the process that contains detailed information about each process sequence, the duration of each process, and who is responsible for that process. Finally, the data from the

workflow is used to improve the details of the work instruction.

TABLE I. ANALYZING THE OVERVIEW OF THE PRODUCTION PROCESS

Supplier/Stakeholder	Input	Process	Output	Customer
1. Vendor supplying hard disk drives to production lines. 2. Quality Control Officer responsible for quality control in the production line. 3. Process Engineers are in charge of the assembly process's automation.	Station download for upload firmware to hard disk.	1. Set up the hard disk firmware download program. 2. Robot imports hard disk to upload firmware according to hard disk model. 3. Check the upload's integrity in the software against the robot interface.	Hard disk with a complete firmware upload.	Customers are interested in purchasing hard drives.
	Station VFT for checking the hard disk function.	1. Set up the VFT program according to the hard disk model. 2. Scan the hard disk F2 Label into VFT program. 3. The robot imports the hard disk to check all the functions of the hard disk.	Hard disk checks the VFT function completely.	
	Station VMI for checking hard disk damage.	1. Set up the VMI program according to the hard disk model. 2. Employees check for damage to hard disk drives. 3. Scan Label F2 into VMI program to compare hard disk serial numbers.	Check for damage and compare with the complete VMI program.	
	Station AOI for checking seal box, packing box, and weight value of hard disk.	1. Set up the AOI program according to the hard disk model. 2. Scan Label F3 into AOI program to compare it with hard disk F2 label. 3. Check the seal box, packing box and weight value compared to the program.	The hard disk is completely packed in the box and has passed the AOI program.	

From the analysis, it could be divided to four stations consisted of download station, (VFT) station, (VMI) station, and automated optical inspection (AOI) station. The functions of each station can be summarized as following:

- Download station works on uploading firmware to hard disks.
- VFT station will inspect the operation of each function of hard disk.
- VMI station inspects damage occurred on hard disk.
- AOI station is the final station for detecting incomplete of hard disk packaging which is consisted of seal box, packing box, and weight.

C. Development of electronic work instruction (WI)

Electronic work instruction are recorded in digital file format that are more efficient than traditional document. And it has benefit of quickly and easily to find, updated or revised at any time, and convenient for keep and well organize. The electronic work instruction can easily be developed using Microsoft Access program. Authentication of use was required to prevent the classify document leak. As shown in Fig.3, the documents were classified based on quality control station and group of machine/tool. The system was also provide the brifely explanation of each work instruction in order to support selection of use. Employee was capable to use mobile device to access to the system. The developed work instruction was visualize in pdf file format. In addition, the developed document was capable of edit or update easily under review permission of authorized middle management team.

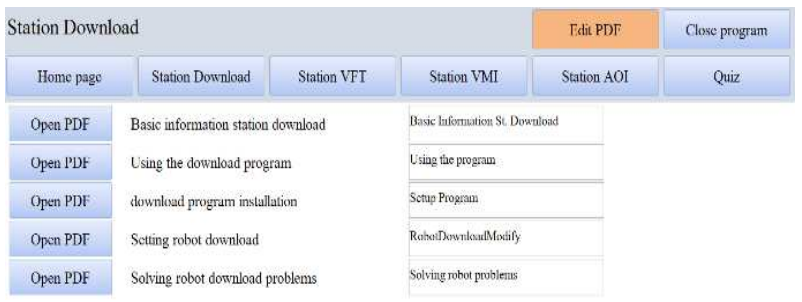


Fig. 4. Interface for electronic work instructions.

Fig. 4 Electronic work instruction is developed through Microsoft Access and connected through a local area network within the factory. It is divided into 3 components as follows: login system , main page and document editing system.

D. Training process

Training of employees in this research uses problem-based learning to be applied in training[4], in collaboration with electronic work instruction. The subjects for the training were selected based on the problems that arose but had the greatest impact on the production process. Therefore, the researchers chose the training content for the topic of configuring AOI waste detection. The detailed steps of training as following[4]:

TABLE II. TRAINING PLAN USING PROBLEM BASED LEARNING

Hierarchy	Process details
Define problem	1. Introductory trainer about the differences of each model of hard disk box and how they are different. using illustrations to describe.
	2. The trainer gave an example of the problem of incorrect AOI settings by using a visual comparison between the good and the bad.
	3. The trainer asked the participants about the difference between the good and the bad from the sample images.
	4. When everyone has answered the trainer then asked about the cause of the problem why the AOI was unable to detect the waste from the preview.
Understand the problem	1. Each participant understands how AOI is adjusted and how it is adjusted. And how does the NEPD model hard disk box have a detection procedure. To enhance understanding of the issue of the problem.
	2. Each participant understood the problem that What is the problem, why can't the AOI program catch it and how to fix it?
Conducting research	1. The trainer provides resources for the trainees to learn about AOI setting for waste detection.
	2. The trainee's study for themselves on the subject they want to learn. from the sources provided.
Synthesize knowledge	1. The participants apply the knowledge gained from the study and research from the resources provided by the trainees. To design a command in the NI vision builder program to detect the waste of the NEPD model hard disk box.
	2. The trainer provides additional advice. When participants encounter problems that are not available in the resources provided.
Summarize and evaluate the value	1. A self-adjusted AOI test participant to detect waste from NEPD model hard disk boxes.
	2. The participants explained the results of the experiments to the trainees
Presentation and evaluation	1. The participants explained the cause of the problem and how to fix the problem why AOI was unable to detect waste from the NEPD model hard disk box.
	2. The trainer explains more about the cause of the problem and introduces additional knowledge to the participants.

IV. RESULT AND DISCUSSION

This research studies the researchers assessed outcomes of the research in three parts: The first part is a comparison of results before and after the implementation of electronic work instruction with stop line recording system. The second part is the satisfaction assessment after training. It is an assessment to check employee satisfaction in terms of the training process. Trainer side and the knowledge and understanding that employees gain after training. And the last part is the employee skill observation.

This is a skill observation during training where the trainer observes and records the results of each employee. The results of all assessments are displayed as follows:

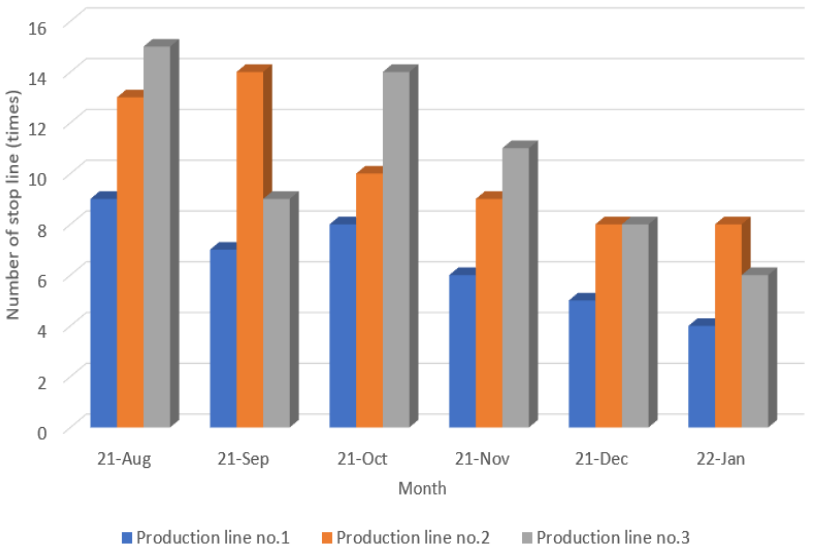


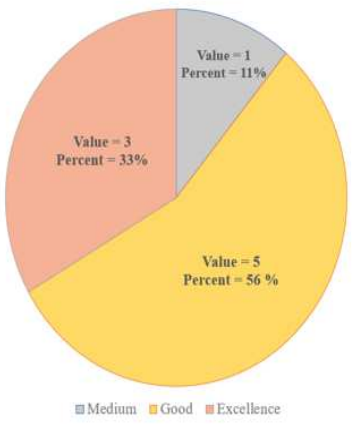
Fig. 5. Results of the production stop line.

From Fig. 5 shows a graph comparing the data of stopping the production process from data collection using the Stop line recording system for collecting the stopping the production process in 3 processes. Consist of station download station VFT station VMI and station AOI. The researchers selected a total of 3 production lines. The results showed a period of 4 months before to the research (August -November 2021). The average stop line for the average stop line for all 3 production lines was 8,12, and 12 times, respectively. Remark that in November there were fewer line stop as production lines were move to open another production line.

The results of the research on the use of electronic work instruction in the production process and training of employees in this research the problem-based learning process was used as a training technique together with electronic work instruction. Fig. shows that throughout the course of two months (December 2021-January 2022), the average stop line for all 3 cell production lines was 5,8, and 7 times, respectively.

TABLE III. THE RESULTS OF THE ASSESSMENT OF PROBLEM SOLVING SKILL

Topic	Mean	SD
Identify problems	3.98	0.64
Collect information about the problem	4.60	0.49
Design problem solving	4.54	0.50
Solve the problem	3.70	0.62
Explain and communicate problems	4.10	0.53
Summary	4.24	0.64



The results of an employee's problem-solving skills analysis to assess the problem-solving skills required for the employee after training. which is divided into 5 processes, consisting of identify problems, collect information about the problem, design problem solving, solve the problem, and explain and communicate problems. The trainers recorded the results of the 9 persons through an observation form on the problem-solving skills of the employees. The results showed that three of the trainees had excellent problem-solving skills, five of the trainees had good problem-solving skills, and one of the trainees had medium problem-solving skills. In conclusion, the problem-solving skills measurement of all participants had a good overall problem-solving skill level.

V. CONCLUTION

This research helps quality control department employees better have problem-solving skills. and reduce production stopping problems that occur in the quality control department. The results showed that the quality control department employee had a good level problem-solving skill overall. and it can reduce the production stop line problem occurring in the station download, station VFT, station VMI and station AOI of all 3 cells production by up to 46.15%.

The researchers foresee two ways to develop this research in the future, consisting of video training in combination with electronic work instructions. This allows each employee to receive training at their own convenient time. and allows for more training on many topics. The last point is creating a training plan for new employees who will be on the job for three months. Because the previous work experience and knowledge of the employees are less than the former employees.

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P02337

Development Innovation-based Learning Model to Study the Creation of Teaching Media for Students of Technical Education Program

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Abstract

The purposes of this research were: 1) to develop an innovation-based learning model for creating teaching materials of technical education students, 2) to study the effect of using an innovative- based learning model for the study of creating teaching materials of the technical education students. The Sample groups of the research were 28 the third-year students with a bachelor's degree in Technical Education, Department of teacher training in electrical engineering at King Mongkut's University of Technology North Bangkok (KMUTNB), the research instruments include with 1) the developed innovation- based learning model, 2) the lesson plan using an innovative-based learning model, 3) assessment form for innovation media, and 4) a student satisfaction assessment form. The research results shown that 1) The results of the assessment of the suitability of the innovative-based learning model by experts were appropriate at a high level (mean = 4.36 and S.D.= 0.55), 2) The results of the students' assessment of the skills in

creating teaching materials on electrical of the learners which passed the criteria at 70 percent and 3) Learners' satisfaction of the developed innovative learning model at a highest level (mean was 4.56 and the standard deviation was 0.68)

Keywords— Innovation-based Learning

Development Innovation-based Learning Model to Study the Creation of Teaching Media for Students of Technical Education Program

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***Keywords*—** *Innovation-based Learning.*

I. INTRODUCTION

National Innovation Agency (NIA), Thailand has given the meaning of innovation that means new things arising from the use of knowledge and creativity that is beneficial to the economy and society. The key elements of innovation include: 1) novelty, 2) usefulness, and 3) use of knowledge and creative thinking. The process of creating innovation works is as follows steps: 1) searching 2) selection 3) implementation and 4) learning. Nowadays is the 21st century era that focuses on technology adoption used in the education to manage teaching and learning to be effective and increase learners' learning achievements. The learners' skills in the 21st century include: 1) learning and innovation skills, 2) information, media, technology skills, and 3) life and occupation [1], where innovation is important greatly to the current study because the globalized world is changing rapidly in every aspect, that focuses on advances in technology and information, therefore education needs to evolve from the old education system to the modernization of technology and social conditions. [2].

From the results of the country's reform plan for the year 2019 found that education management is inconsistent and responsive to the changes in the country in the 21st century where digital technology and innovation plays an important role, this reflects that teaching and learning according to the curriculum alone may not be enough. Therefore, applying appropriate research and learning model are essential to encouraging students to apply their knowledge and skills to apply in practice that is consistent with learning in the 21st century.

Innovation-based learning is a learning style that encourages learners to develop innovations themselves and promotes the learning development of learners throughout the period of innovation development, as a result, students understand the process of innovation and develop creative thinking skills, systematic thinking skills, problem solving skills, decision-making skills, leadership skills, and teamwork skills, etc. which is skills of innovators. [3]

The Innovation and Instructional Media subject is a course in the bachelor's degree in Electrical Engineering and Education program, Department of teacher training in electrical engineering, Faculty of Technical Education at King Mongkut's University of Technology North Bangkok (KMUTNB) which provides teaching and learning to educate and train learners' skills in creating innovative instructional media, the condition of teaching and learning was found that 1)the students still lacked the thinking process in creating new educational innovations and 2) Students create projects that still lack innovation. Therefore, the researcher has an idea to encourage learners to create innovative skills in an instructional media, which developed an innovative-based learning model for education in the creation of teaching media.

A. Purposes of the research

1. To develop an innovation-based learning model for the study of the creating teaching media of the technical education students.

2. To study the effect of using an innovation-based learning model for the study of creating teaching media of the technical education students.

A. Research hypothesis

1. Innovation-based learning model for the study of creating teaching media of the technical education students were appropriate at a high level.

2. Learners had a score of skills in creating teaching medias in the electrical field at 70 percent.

3. Learners' satisfaction with developed innovation-based learning model at a high level.

II. Learning and Teaching Theory

A. Innovation-Based Learning

Innovation is bringing new things such as ideas, actions, inventions into changes or additions from old methods for better usability. The characteristics of innovation that have been attracted and used widely are as follows: 1) not complicated 2) not expensive 3) readiness for use 4) innovation that does not affect the original product 5) concrete and clear.

Learning innovation is facilities that enable teachers to design learning management with focus on student-center, students are exposed to various situations which will lead to learning, inventing, and practice, resulting in skills and expected features, Innovations for learning management that are good for teachers should be innovations that are easy to use, useful and do not affect traditional learning methods which can be divided into *2* types: 1) Different types of learning materials and 2) Techniques and methods of learning [4]

III. Implementation

This research was experimental research with the one sample group to validate the efficiency of the innovation-based learning model. The research methods were as follows:

A. Defining a sample group

The sample group was 2nd year bachelor's degree students in Electrical Engineering and Education, Department of Teacher Training in Electrical Engineering, Faculty of Technical Education at King Mongkut's University of Technology North Bangkok (KMUTNB). There were 28 students enrolled in the innovation and instructional media subject that selected using a purposive sampling.

B. design of online learning model

The researcher has studied the relevant data and research, then design an innovative-based learning. The process of developing innovation in teaching and learning using 5D innovation development process, the steps of the innovation development process using 5D Innovation Development Process, which has the following steps:

1) Step 1 (discover): Instructor defines the topics and key points of innovation media for learners to search and invent innovations related to media used for teaching and learning in electrical and electronics.

Fig.1. Discover step by 5W1H method

2) Step 2 (design): Students design the structure of innovative learning media in electrical and electronic fields.

3) Step 3 (develop): Learners create an innovative prototype media for electrical and electronic learning as designed in step 2

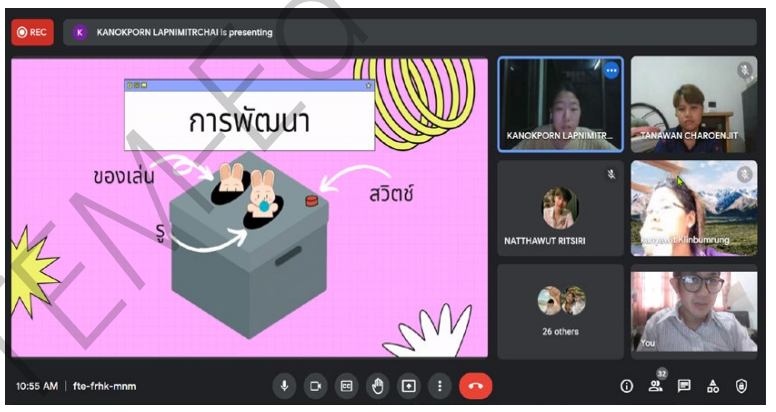

Fig.2. Design and Develop step

4) Step 4 (deploy): Students publish the work in media form such as posters, presentations, AR media, video etc.

5) Step 5 (drive): Summary of the results of the trial and disseminating innovative media for used teaching and learning in electrical and electronics

Fig.3. Example for deploy step with augmented reality (AR) media

C. Development of research tools.

The researcher creates and develops the research tools used for research. The research tools consisted of 1) the developed innovation-based learning model, 2) the lesson plan using an innovative-based learning model, 3) an innovative media assessment form, and 4) a student satisfaction assessment form.

D. Finding the quality of research tools.

The quality assessment of the designed innovative-based learning model which assessment from 5 experts found that the results of the suitability assessment were at appropriate at a high level, the researcher improve the research tools and then try out with a group that is similar to the sample group which test the effectiveness of the research tool for implement with sample group

E. Try out with a sample group.

The researcher used the improved research tools try out with a sample group which 28 students with a 2nd year bachelor's degree in Electrical Engineering and Education, Department of Teacher Training in Electrical Engineering, Faculty of Technical Education at King Mongkut's University of Technology North Bangkok (KMUTNB). Selection using a purposive sampling in Semester 2/2021, duration of learn 5 weeks (5 hours/week)

IV. Research Results

This research is the development of an innovation-based learning model. After that experimenting with the sample group, the results were statistically analyzed such as mean, standard deviation which can summarize the research findings into 3 parts as follows:

A. The quality results of developed innovation-based learning model.

The quality assessment of the developed innovative-based learning model which assessment from 5 experts who teach teaching in innovation and instructional media as shown in table I.

TABLE I. QUALITY OF DEVELOPED INNOVATION-BASED LEARNING MODEL (N=5)

Evaluated topics	$\overline{X}$	S.D.	Interpret
1. Appropriateness of the learning management plan	4.40	0.55	high
2. Appropriateness of the overall elements of the innovation development process	4.60	0.55	highest
3. Appropriateness of the innovation discovery stage	4.60	0.55	highest
4. Appropriateness of the innovative design stage	4.40	0.55	high
5. Appropriateness of the innovation prototype development stage	4.60	0.55	high
6. Appropriateness of the innovation trial stage	4.60	0.55	highest
7. Appropriateness of the summary and follow-up steps	4.20	0.84	high
8. Appropriateness of the tools used	4.40	0.55	high
9. Appropriateness of innovation media assessment items	4.20	1.10	high
10. Appropriateness of teaching and learning activities	4.40	0.55	high
average	4.36	0.55	high

From Table 1, the results of the assessment of the quality of the developed innovative-based learning model on the 5 experts found that the overall assessment results in all topic were appropriate at a high level (mean = 4.36 and S.D.= 0.55)

B. The assessment results of the skills in creating teaching innovative media

The evaluation results for skill in creating teaching innovative media for electrical and electronics. Evaluate topic consist of 1) innovation discovery, 2) Innovative design, 3) Development of innovative prototypes, 4) The use of innovative media for teaching and learning in electrical and electronics and 5) Conclusion of the implementation. Results as shown 14 projects in table II.

TABLE II. THE SCORE OF THE ASSESSMENT IN SKILLS OF CREATING TEACHING INNOVATIVE MEDIA (N=28)

Evaluated topics	$\overline{X}$	Interpret
1. Automatic plant watering machine	80	good
2. Automatic waste bin	87	good
3. Quiz game	85	good
4. Automatic tree care machine	80	good
5. Automatic alcohol sprayer	72	moderate
6. Auto switch via mobile phone	79	moderate
7. Cat toy	86	good
8. Alcohol dispenser	74	moderate
9. Pet food machine	81	good
10. Bangle S.O.S.	84	good
11. Smart vacuum cleaner	78	moderate
12. Smart mail box	89	good
13. Document sterilizer	76	moderate
14. Smart thermometer	73	moderate
Average	**80.3**	good

From Table II, the students' evaluation results of the skills in creating teaching innovative media for electrical and electronics were average equal to 80.30 which passed the criteria (70 percent).

D. The analysis results of students' satisfaction.

The students take a satisfaction assessment at the end of the teaching process with an innovation-based learning model, the questionnaire using 5-level rating scale shown in table III.

TABLE III. The results students' satisfaction. (N=28)

Evaluated topics	$\overline{X}$	S.D.	Interpret
1. Help learners to seek knowledge by themselves as well.	4.63	0.61	highest
2. Help students to combine knowledge in many fields together.	4.5	0.73	highest
3. Help support lifelong learning	4.5	0.81	highest
4. New and interesting learning style.	4.63	0.61	highest
5. Help learners take responsibility for assigned tasks.	4.56	0.62	highest
6. Stimulates the creative thinking process of learners.	4.75	0.57	highest
7. The learning activities are fun and not boring.	4.25	0.85	high
8. Learners gain a wide range of knowledge.	4.63	0.61	highest
9. Learners are able to apply the skills they have acquired for project work and media in other subjects as well.	4.60	0.63	highest
10. Learners have developed their own learning potential better than normal forms of learning.	4.56	0.72	highest
Average	4.56	0.68	highest

From Table III, the students' satisfaction on innovation-based learning model at a highest level (mean is equal to 4.56 and S.D. is equal to 0.68), when considering the topic, it was found that the learners had satisfaction on the stimulates the creative thinking process of learner's topic with the highest level of satisfaction (mean is equal to 4.75 and S.D. is equal to 0.57),

V. CONCLUSIONS

This research aims to develop an innovation-based learning model for creating teaching materials of technical education students. The research found that 1) the quality results of developed innovation-based learning model was appropriate at a high level which mean = 4.36 and S.D.= 0.55, 2) The students' evaluation results of the skills in creating teaching innovative media for electrical and electronics with a average total is equal to 80.30 which passed the criteria at 70 percent and 3) the learners had satisfaction on an innovation-based learning model at a highest level 4.56 and S.D. is equal to 0.68, that is consistent with the research of Paradorn[3], studies the effect of innovation-based learning on twenty-first century skills and learning experiences among nursing students, the results showed that the twenty-first century skills score after the experiment was higher than before the experiment in the experimental group ($p<0.05$). Additionally, the twenty-first century skills score in the experimental group was higher than the control group ($p<0.05$). The experimental group was at a high level for learning experiences with innovation-based learning (mean= 4.01, S.D. = 0.01). Therefore, the innovation-based learning (IBL) can be promoted learning skills in twenty-first century and learning experiences should be used as a guideline of extracurricular activities and developing innovative production processes

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The Use of Digital Technologies for Reading Tests by STEM Learners

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Abstract

This paper was aimed to examine the use of digital technologies for reading tests by STEM learners. In this paper, the researcher studied how STEM learners used translation tool (Google Translate), search engines and online authoritative dictionaries (Oxford, Cambridge and Merriam-Webster) and how they performed in reading tests. It was found that students preferred to use digital technologies when they tackled reading tests. However, tests should be individualized and that the format of assessment should be changed from multiple choices to graphic organizers.

Keywords— digital technologies, English as a Foreign Language (EFL), Google Translate, online dictionaries

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The Use of Digital Technologies for Reading Tests by STEM Learners

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I. INTRODUCTION

The use of technologies in language learning is not new. In the past, there was an approach called "Computer-Assisted Language Learning" or CALL, which emphasizes the use of computers to help students learn and practice foreign languages inside language laboratories and outside classroom [1-3]. It is popular with English as a Foreign Language (EFL) classrooms. Generally, computer software was installed on computers and students ran it to read texts, listen to audio clips, watch video clips and do exercises on their own without connecting to the internet. That is an offline mode of learning in the 1980s and 1990s. When the internet arrived in the late 1990s and became popular in the early 2000s, this new technology changed the way students and teachers used computers for language learning. Therefore, researchers suggested a new approach called "Technology-Enhanced Language Learning" or TELL, which emphasizes the use of technology to enhance the contents and the way students learn foreign languages. Since then, the use of technologies in English language classrooms has become more and more influential and it has changed the way both learners and instructors interact with technologies in EFL classrooms [1-3].

Although the use of technologies is prevalent in EFL classrooms, such use is often limited and secondary in comparison to the traditional face-to-face classroom attendance. Before the Covid-19 pandemic, students needed to attend classrooms and computer laboratories to learn with the teachers and the instructors. When students encountered a difficulty, they could ask for advice and learned how to use the technologies correctly. However, the global pandemic forced many classrooms around the world to become 100% online or virtual instantly. Students and teachers have to engage in online classrooms through technologies. Some technological tools are new and both teachers and students have to learn how to use them effectively within a short amount of time. Other tools are not new but students might not know how to use them effectively when they cannot learn from their teachers. In some cases, students might misuse those technologies. This is an area of research which this paper addresses.

II. LITERATURE REVIEW

This section will review the following aspects of technologies in English language learning: historical development of CALL and use of technologies in English language learning.

A. Historical Development of CALL

Li [1] proposes that there are four stages in the historical development of computer-assisted language learning and suggests that we need to move from the term "Computer-Assisted Language Learning" to the term called "Technology-Enhanced Language Learning" or "Mobile-Assisted Language Learning" because nowadays we rely less on computers and more on mobile devices.

Stage 1: Structural CALL (1970s to 1980s). In this stage, computers are used to provide tutorials to learners and learners learn by doing exercises and receiving corrective feedback. It supports the drill-and-practice method, i.e. practice makes perfect. The focus of this stage is to gain linguistic accuracy through the use of technologies [1-3].

Stage 2: Communicative CALL (1980s to 1990s). In this stage, computers are used to provide language input to learners and learners learn by analyzing the input and giving their response. It supports the communicative approach, in which learners are exposed to language in a simulated situation and discover their own learning outcome in a meaningful context. The focus of this stage is to gain communicative competence and fluency through the use of technologies [1-3].

Stage 3: Integrative CALL (1990s to 2000s). In this stage, computers are used to provide information and multimedia to learners and learners learn by integrating both content and language through their receptive and productive skills. It supports the principles of authentic discourse and English for specific purposes (ESP), in which computers facilitate

access to real language usage in different social contexts and different social groups. The focus of this stage is to gain access to informative resources and apply them to tasks and projects at hand through the use of technologies [1-3].

Stage 4: Collaborative TELL or MALL (2000s onwards). In this stage, computers are used to provide opportunities to learners so that learners can participate in collaborative tasks and projects. It supports the social constructivism approach, in which many learners co-construct their knowledge. It is a shift from the view that learners acquire knowledge towards the view that learners participate in knowledge construction with their peers and teachers. The focus of this stage is to gain autonomy and participation through the use of technologies [1-4].

B. Use of Technologies in English Language Learning: the Good and the Bad.

Several technologies in English language learning have been praised by researchers because they can assist learners in acquiring the target language and enhance their learning experiences [1-3]. In the past, there were CD-ROM versions of dictionaries by authoritative publishers such as Oxford University, Cambridge University and Merriam-Webster's. Then, there were applications for students to practice language skills such as Rosetta Stone and English Discoveries. After that, many English corpuses started to become available and advanced learners could use these resources to be exposed to authentic language to learn about collocations and to express English naturally. Nowadays, the Internet is only one click away and learners have a vast amount of information at hand.

Technologies have also allowed learners to study English anywhere, anytime. In addition to traditional face-to-face classrooms, there are distance learning, blended learning, online learning and mobile learning to meet different needs of learners [5-6]. Therefore, instructors gain a new role of facilitator to support the learning journey of each student.

However, the issue of assessment is one area of concerns regarding the use of technologies in English language learning [7-8]. While some instructors still use traditional assessment such as tests, others suggest that alternative assessment should be taken into account, such as portfolios and projects [9-10].

Another problem regarding the use of technologies is about translation tools. It has been noted that students nowadays use Google Translate to write their assignments and to do their reading tasks. Although one study [11] shows that GT is useful, another [12] suggests otherwise because by doing so, students bypass or circumvent their understanding of the target language. Instead of using technologies to enhance their English learning experience, they do not gain much benefit from using technologies. It might be a kind of cheating as well [4]. Moreover, with the pandemic, alternative forms to assessment are needed to help students learn better [13].

III. METHODOLOGY

A. Research Questions

The research questions for this study were as follows:

- How do STEM learners use digital technologies when they tackle reading comprehension?
- How do STEM learners perform in reading tests when they use or do not use digital technologies?
- What are STEM learners' attitudes towards the use of digital technologies during tests?

B. Data Collection and Analysis

The researcher collected the data from one university in Bangkok. The focus was on STEM learners; hence, two faculties—Faculty of Engineering and Faculty of Veterinary Medicine—were chosen for this research. The data were from the researcher's observation in the classrooms and the questionnaires provided to students to fill out on a voluntary basis.

IV. RESEARCH FINDINGS

The research findings will be presented in two aspects: tackling reading comprehension and taking online tests.

A. Tackling reading comprehension through machine translation, search engine and dictionary lookup

According to the survey on the use of technological tools to look up vocabulary at the beginning of the online classrooms, 99 respondents (88.4%) used Google Translate. 46 respondents (41.1%) used Longdo, (a Thai company which provides dictionary lookup functionality between English and Thai). 34 respondents (30.4%) used an Oxford dictionary and 30 respondents (26.8%) used a Cambridge dictionary.

According to the observation of students' tackling reading passages by the researcher, it was found that some students used automatic translation of texts or webpages. When the texts appeared on browsers, these students could install an extension to automatically translate everything into Thai. They could also use an app on their mobile phones to take a photo of the texts and translate everything.

Moreover, some students paid attention to questions first before they read the reading passages. They would scan the passages for the exact words and then chose the choices which corresponded to the questions. They did not read the rest of the reading passage. In other words, some students would search and find only the words in questions and answers and ignore the whole text.

When some students noticed bad translations, they tried to find the real meaning of those words by typing such words in Google search engine instead of using Oxford or Cambridge. To help students gain a better

understanding of specific vocabulary, the instructor taught the students to look up words in Oxford, Cambridge and Merriam-Webster through context clues. It turned out that these students were not familiar with the layout of the dictionaries. Since Google Translate provided only translations in two boxes (left and right), it looked clear and simple. However, authoritative monolingual dictionaries required students to read many lines before they could find the right definitions. The instructor had to help these students by teaching them how to use dictionary entries to tackle words with multiple definitions to identify a more suitable definition in each context. After two months have passed, students were asked whether they used any authoritative dictionaries in the past month, 54 respondents (74%) reported that they had used while 19 respondents (26%) still preferred to type in Google search engine to find the meanings.

TABLE I. PREFERENCES AFTER TWO MONTHS

Respondents	N	%
Using authoritative dictionaries	54	74%
Using Google services	19	26%
Total	73	100%

B. *Taking tests with and without the use of digital technologies*

In this study, the term "test" is used to mean both quiz and test. Each quiz accounted for 5% of the total score of a course whereas a test accounted for 10% or more of the total score of a course. The findings from the survey on the goal of tests with and without the use of digital technologies are presented in Table 2.

TABLE II. TAKING TESTS WITH AND WITHOUT THE USE OF DIGITAL TECHNOLOGIES

Item	$\bar{x}$	S.D.	Level
Using technologies during an English test can improve my English.	4.21	0.75	Very High
The goal of an English test is about communication.	3.96	0.87	High
The goal of an English test is about knowledge.	3.75	0.78	High
The goal of an English test is about vocabulary and meaning.	3.75	0.83	High
When I am successful in learning English, I don't need GT.	3.71	1.01	High
The goal of studying English is to become bilingual.	3.68	0.94	High
The goal of an English test is about comprehension.	3.62	0.79	High
The goal of an English test is about grammar and correct usage.	3.49	0.91	High
Using GT is better than using Oxford, Cambridge and Merriam-Webster's.	2.93	1.06	Medium
By using technologies, I don't need to memorize vocabulary.	2.58	1.25	Medium

According to Table 2, the majority of STEM learners preferred to use technologies during their tests ($\bar{x}$ = 4.21, S.D. = 0.75). In other words, they would like an online test to follow the format of an open-book examination in which they could browse freely to answer the questions. Still, they were aware that using Google Translate was not as good as using authoritative dictionaries such as Oxford, Cambridge and Merriam-Webster's ($\bar{x}$ = 2.93, S.D. = 1.06). Regarding the goal of an English test, the goal with the highest mean score was about communication ($\bar{x}$ = 3.96, S.D. = 0.87). It seems that when they are successful in learning English, they might not need Google Translate ($\bar{x}$ = 3.71, S.D. = 1.01).

STEM learners also expressed many open-ended views towards the use of technologies during tests in the questionnaire and their views could be grouped into two categories: language skills and concepts. With regards to language skills, students believed that using digital technologies such as Google Translate, search engine and online dictionaries during tests was good and should be allowed because English language was their barrier to communicate their ideas correctly. One student said that everybody in class had different levels of language skills. So, they wanted to use these tools to achieve their learning goal. Another student claimed that there were too many English words to remember and that it was acceptable to use a translator tool to keep up with the demand of English classrooms. With regards to contents, some students argued that they wanted to understand the contents in the reading passage clearly and that using technologies to look for more information online could help them achieve this purpose. A few students acknowledged that when it came to writing tasks, copying contents from the internet or other sources was a bad practice.

According to the observation and the assessment of both quizzes and tests, writing tasks which allowed students to use technologies turned out to be clearer and easier to read. Reading tasks which allowed students to use technologies showed a higher performance among students. However, the use of technologies did not reflect the actual competence of these students. At least 10% of students used or copied online contents in their writing tasks. It was obvious that some of them used contents written in Thai from Thai websites and used Google Translate to translate them into English to avoid plagiarism detection software. Regarding the reading tasks, at least 10% of students could not remember anything of the reading passages after 30 minutes.

In order to deal with this issue, the instructor decided to change the format of assessment. With reading tasks, students were required to write a graphic organizer from the texts instead of choosing multiple choices to questions. With writing tasks, students were required to write about themselves in details. Moreover, the written essays were replaced by video recordings of themselves talking about their opinions towards the topic of their choice. In this way, students were more active in their learning. They

could still use technologies to achieve their learning goal. However, the problem with this technique was that each student was given a different reading passage or a different topic. Otherwise, they would start to copy from their friends. Fig. 1 shows some graphic organizers from one reading task assigned to one student. It can be seen that each paragraph or section of the passage could be organized. Here, there are a pyramid, a food chain, and a problem-solution diagram.

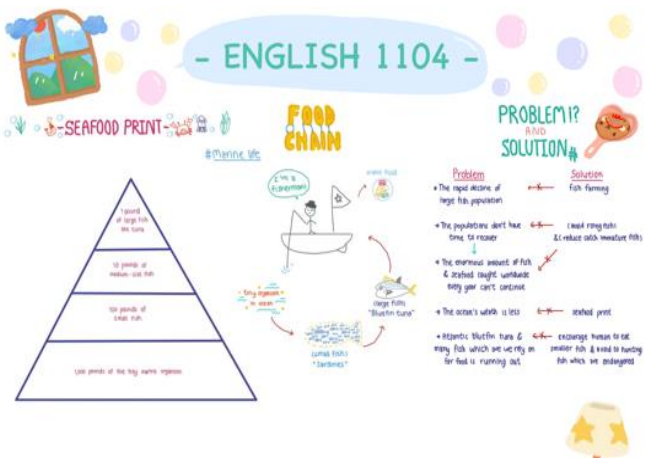

Fig. 1. Example of graphic organizers from a reading task

V. DISCUSSIONS

In this study, the majority of STEM learners used digital technologies in their English language learning. Nearly all used Google Translate to tackle their reading comprehension in their reading passages and to look up vocabulary because it looks clearer and simpler than using authoritative dictionaries which requires reading many lines before finding the right definition. This practice is alarming as discussed by Ducar and Schocket [12] in that the use of technologies can bypass the actual understanding of the target language. Moreover, the problem with Google Translate and Longdo is that their databases are based on open source data, automation, and volunteer basis. Therefore, it is important to teach students how to use dictionaries to get a better understanding of the target language. Still, there is a concern that the habit of using Google Translate and search engine is difficult to change. So, it is a good idea to conduct a research study about how to help students to get into the habit of using authoritative dictionaries in order that they can learn the target language and achieve their learning goal through a better choice of technologies.

Moreover, the majority of STEM learners believed that using technologies during tests could improve their English. Traditional assessment or tests are not suitable because the use of technologies to achieve such purpose did not enhance learners beyond the tests. Therefore, it is important to provide more active tasks such as drawing a graphic organizer and talking about themselves in order to engage learners with both contents and technologies. Still, there is a concern here that learners might be too dependent on technologies to study English. Without technologies, learners might feel stressed because they did not know what to do. This is another aspect which is worth investigating in future research studies.

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P02360

Causes of Low Mathematics Achievement in Uganda and Exploiting ICT-based Tools in Response

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Abstract

This study focuses on mathematics education by using cognitive linguistics and developmental psychology to identify the causes of low levels of mathematics achievement in Sub-Sahara African countries. It also develops and adapts tools to directly investigate the causes in detail. Drawing on these perspectives, we suggested the following hypotheses: The real world and the mathematical concepts are disconnected because of the lack of appropriate metaphors, and the underdevelopment of the mental number line is an impediment to learning outcomes. The mental number line is considered the foundation of the quantity concept and basis of calculation skills. A survey was conducted to elucidate the hypotheses by using a questionnaire involving addition and subtraction with negative numbers and a number line task that can measure the development of a mental number line. We found that our hypotheses were generally correct. At the same time, we created application that automatically calculate the indicator of mental number line and the self-

learning tool with AR. In the survey, we investigated whether using this tablet program is be accepted by Sub-Sahara African pupils.

Keywords— Metaphor, Negative Numbers, Mental Number Line, Augmented Reality

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Causes of Low Mathematics Achievement in Uganda and Exploiting ICT-based Tools in Response

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***Abstract*—This study focuses on mathematics education by using cognitive linguistics and developmental psychology to identify the causes of low levels of mathematics achievement in Sub-Sahara African countries. It also develops and adapts tools to directly investigate the causes in detail. Drawing on these perspectives, we suggested the following hypotheses: The real world and the mathematical concepts are disconnected because of the lack of appropriate metaphors, and the underdevelopment of the mental number line is an impediment to learning outcomes. The mental number line is considered the foundation of the quantity concept and basis of calculation skills. A survey was conducted to elucidate the hypotheses by using a questionnaire involving addition and subtraction with negative numbers and a number line task that can measure the development of a mental number line. We found that our hypotheses were generally correct. At the same time, we created application that automatically calculate the indicator of mental number line and the self-learning tool with AR. In the survey, we investigated whether using this tablet program is be accepted by Sub-Sahara African pupils.**

Keywords—metaphor, negative numbers, mental number line, Augmented Reality

I. INTRODUCTION

Mathematics achievement in numerous Sub-Sahara African countries does not meet world standards [1]. Education support for Sub-Sahara African countries is required for them to meet the Sustainable Development Goals. It is necessary to understand concepts around number and other mathematical concepts to be able to do math. Cognitive linguistics studies have shown that number concepts and mathematical concepts rest on metaphors [2]. The importance of metaphor is widely recognized in mathematics education [3]. One mathematical concept in particular requires a metaphor, that is, negative numbers. Negative numbers are highly abstracted numbers that cannot be demonstrated such that we can use concrete objects to demonstrate two bananas and a half of a banana. The ability to understand negative numbers may be a criterion for metaphorical learning. The calculation skills of Zambian pupils for addition and subtraction with negative numbers are poor. It has also been noted that these pupils have difficulty linking negative numbers to real life examples and low-achievement pupils cannot easily draw number lines [4]. The study of number recognition by using number lines has identified mental number lines in developmental psychology. The mental number line is the basis for acquiring number and quantity schemas and is also the basis for basic calculation skills, such as addition and subtraction. To measure the ability to use the mental number line, a number line task is given, which requires estimating the placement of a number on a number line. These estimations become more accurate throughout childhood development [5][6][7].

We hypothesize the following reasons for the low mathematics achievement of pupils in Sub-Sahara African countries.

Hypothesis 1: The real world and mathematical world have become disconnected because of a lack of appropriate metaphors.

Hypothesis 2: The underdevelopment of the mental number line, that is, the ability to properly estimate numbers on the number line, is an impediment to learning outcomes.

The primary objective of this study apart from verifying the hypotheses is to develop a means of improving the low level of mathematics achievement in Sub-Sahara African countries. Therefore, we have developed a tool to link the real world with the numerical world and to promote the development of the mental number line in school mathematics instruction. There are some studies that suggest that computing training, physical movement, and the use of the virtual number line support the understanding and development of the mental number line [8][9]. To this end, augmented reality (AR) technology has been adopted for improvement of pupils' mathematics achievement in our study. However, is tablet learning possible for Sub-Sahara African pupils who have never used a tablet before? Therefore, we conducted a survey in Republic of Uganda (Uganda) on March 2022 to verify the hypothesis and the adaptability of tablet based learning in anticipation of future use of AR applications. This paper reported mainly possibility of the tablet based learning method.

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II. METHODOLOGY

A. Methodological outline

To verify the hypotheses and understand the current state of metaphorical leaning, we developed simple calculation tests of addition and subtraction by using negative numbers. The test included 32 questions and involved the use of a number line. The task was to identify the number indicated by the arrow on the number line. We used a number line from 0 to 100 and another from 0 to 1000. We used percentage of absolute error (PAE) as the indicator of the accuracy of the estimations [5]. PAE is the difference between the number presented and the number estimated divided by the scale of the number line according to the following formula.

$$\frac{|Indicated\ number - Estimated\ number|}{Scale\ of\ number\ line} \times 100$$

For example, if the estimated number is 30 on the 0 to 100 number line with an indicated allowance of 20, PAE = |20 - 30|×100 / 100 = 10%.

To verify the adaptability of tablet based learning, we developed a tablet application that automatically calculates PAE. That application displays a number line and target number on the tablet and a pupil points the location of target number on the number line. Additionally, application has a simple self-learning function of addition and subtraction of integers with number line. Pupils were allowed to use the application freely for approximately 1 hour following our instructions on the tablet as shown in Figure 1(left).

In addition, we developed an application for learning number line using AR as shown in Figure1(right). This application uses AR to map a number line in the real world and pupils can walk on it. Numbers are presented on the tablet, and pupils walk along a number line up to the presented number and then tap the button. The tablet indicates whether the correct position was reached. The iPad was selected as the tablet, and Unity was selected as a programming language. We have not verified the effect of the AR tools, but we let the pupils to play with it for better functional development.

Fig. 1. Using the tablet application (left) and the function of AR applocation (right)

B. Outline of survey

The participants were 60 pupils from the 6th grade (P6) in primary school located in Kampala, Uganda. After the longest school interval of school closure in the world due to COVID-19, the 6th grade pupils here started to learn Integers from January 2022. Hence, we have chosen P6 pupils in Uganda to take the survey from March 9 to 14, 2022.

III. RESULTS

We conducted paper tests involving simple calculation with negative numbers and a number line task. An analysis was performed with 45 respondents, excluding 15 pupils who responded beyond the scale of the number line, as shown in Figure 2.

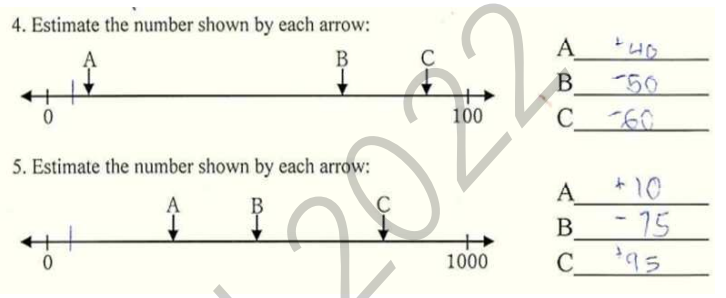

Fig. 2. Example of excluding answer

A. Result of calculation test

The results of calculation tests as shown in Table I.

TABLE I. RESULTS OF CALCULATION TEST
(N = 45, AVERAGE OF % CORRECT 35.0, SD = 15.260)

Questions	% correct	Questions	% correct
4+2	73.6	2+(+6)	60.4
6−4	69.8	4+(−8)	24.5
−8+4	34.0	−4+(+8)	15.1
−4−2	20.8	−2+(−6)	32.1
4+(+2)	58.5	4− (+6)	26.4
8+(−2)	24.5	2− (−4)	26.4
−4+(+2)	18.9	−2− (+6)	18.9
−6+(−2)	26.4	−6− (−8)	24.5
8− (+2)	22.6	0+4	79.2
6− (−2)	26.4	0−4	13.2
−4− (+2)	17.0	0+(+4)	62.3
−6− (−2)	22.6	0+(−4)	43.4
2+6	83.0	0− (+8)	26.4
4−8	17.0	0− (−8)	43.4
−6+8	17.0	4− (+4)	41.5
−2−6	20.8	4+(−4)	30.2

The calculation test results revealed inadequate knowledge of addition and subtraction with negative numbers. However, addition and subtraction without negative numbers showed a high percentage of correct responses. Therefore, the challenge lies in the negative numbers.

B. Result of number line task

We conducted two types of number line task from 0 to 100 and from 0 to 1000, as shown in Figures 3 and 4. The allowances on the 0 to 100 number line tasks are indicated at 20, 50, and 70 and at 10, 70, and 90. The allowances on the 0 to 1000 number line task are indicated at 300, 500, and 800.

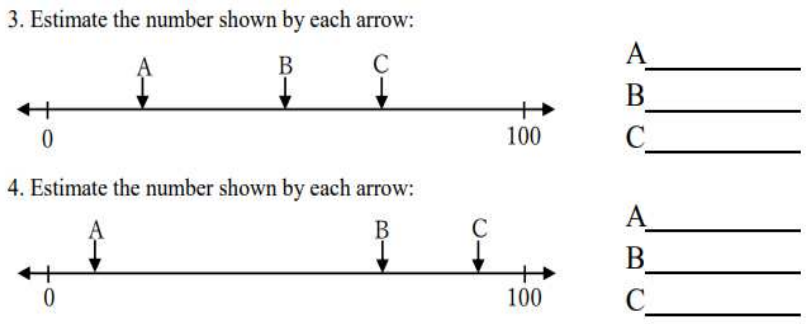

Fig. 3. 0 to 100 number line task

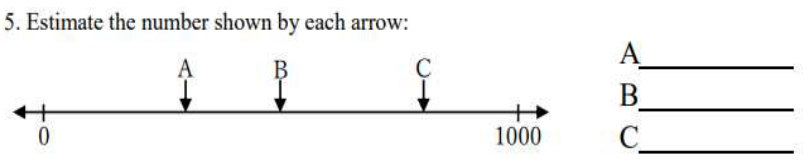

Fig. 4. 0 to 1000 number line task

Tables II and III shows the percentage absolute error of each number line task is calculated.

TABLE II. RESULTS OF PERCENT ABSOLUTE ERROR (0 TO 100 NUMBER LINE TASK)

Indicated numbers	Average of PAE (%)	Standard deviation
20	11.8	13.425
50	17.3	17.158
70	20.9	21.965
10	9.4	17.943
70	23.4	23.950
90	27.4	32.262
Average	18.3	21.117

TABLE III. RESULTS OF PERCENT ABSOLUTE ERROR (0 TO 1000 NUMBER LINE TASK)

Indicated numbers	Average of PAE (%)	Standard deviation
300	65.7	18.161
500	58.1	25.608
800	49.9	32.067
Average	57.9	25.279

In a study in American pupils, percentages of absolute error for 0 to 100 number line tasks administered to first and second grade pupils are 18% and 15% respectively [5]; the same on the 0 to 1000 number line task in second and fourth grade pupils are 19%, 17% respectively [6][7]. Thus, the P6 pupils' average value of the PAE in Uganda is about that of second grade pupils in America. From these results, the development of the mental number line among Ugandan pupils is inadequate.

C. Correlation between test score and PAE

Several researches have investigated the positive correlation between the development of mental number line and mathematics achievements in developed countries [5][8]. We analyzed the correlations between the test scores (number of correct answers) and PAE, as shown in Figures 5, 6, and Figure 7. From these results, a weak negative correlation between test scores and PAE. As a result, there is a positive correlation between the development of the mental number line and mathematics achievement in Ugandan pupils.

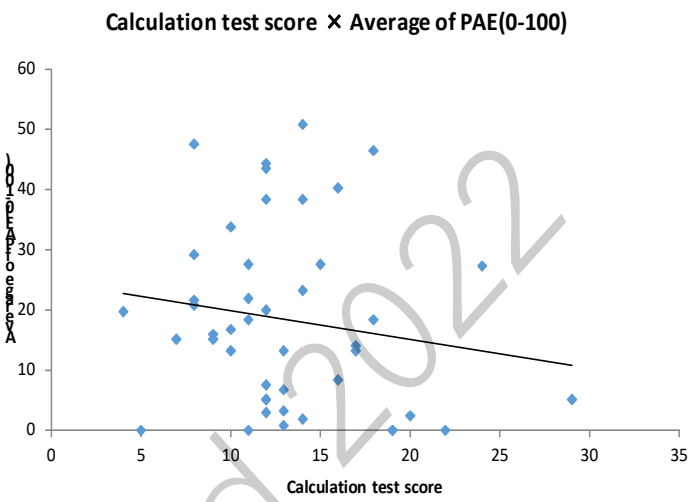

Fig. 5. Correlation between test scores and PAE on the 0 to 100 number line task (n = 45, correlation coefficient −0.155)

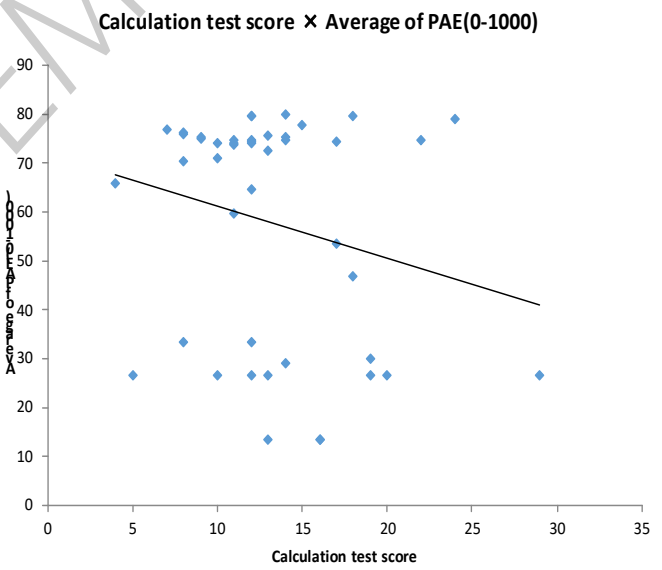

Fig. 6. Correlation between test scores and PAE on the 0 to 1000 number line task (n = 45, correlation coefficient −0.223)

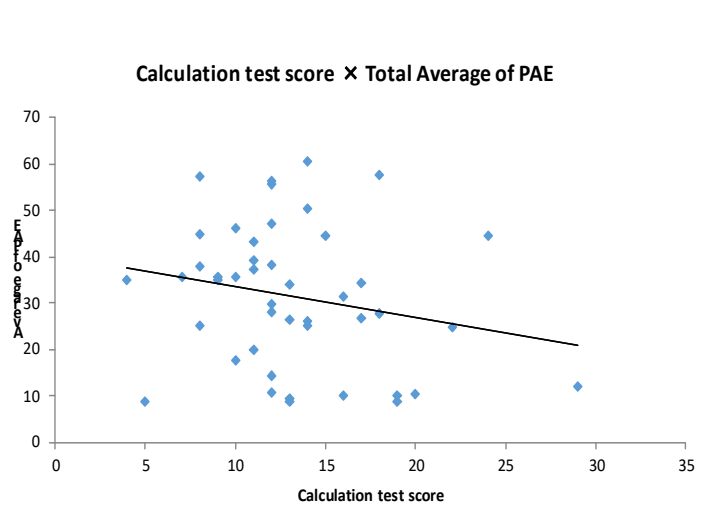

Fig. 7. Correlation between test scores and total PAE including both number line tasks (n = 45, correlation coefficient −0.217)

D. Result of subjective evaluation questionnaire

Before conducting the subjective evaluation questionnaire, we let the pupils play the AR applications in order to confirm some functional

improvements. Therefore, the result of subjective evaluation questionnaire includes the impressions of AR application. The subjective evaluation questionnaire uses a 5-point scale and comprises the following three questionnaire items.

1. Which was easier for you to understand: the ordinary lesson or the self-learning with iPad?
2. Would you like to use the iPad number line learning app for continuous self-learning?
3. Did you enjoy learning on the iPad?

For item 1, 5 indicates easier to understand using the iPad, and for items 2 and 3 indicates strong agreement. The results are shown in Table IV.

TABLE IV. RESULTS OF SUBJECT EVALUATION QUESTIONNAIRE (N=45)

	Average	Standard deviation
Item 1	4.95	0.302
Item 2	4.86	0.668
Item 3	4.87	0.661

The survey results show that the pupils scored 4.8 or higher on all 5-point scale items, which indicates that Ugandan pupils enjoyed the iPad learning preferably. Moreover, we think there is a possibility that these tools can be used to improve achievement in mathematics.

IV. DISCUSSION

In this study, we proposed two hypotheses. The low achievement for addition and subtraction with negative numbers and the high percentage of correct answers for calculations without negative numbers suggests a difficulty in understanding the concept of negative numbers. Because metaphors may be necessary for the conceptual understanding of negative numbers, it is possible that appropriate metaphors are not being used when learning. This result supported Hypothesis 1. Furthermore, we found that the PAE in Ugandan pupils was very high relative to scores of pupils in the United States [5][6][7]. This result indicates an underdeveloped mental number line, thereby affirming Hypothesis 2. We further found a positive correlation between the development of mental number line and mathematics achievement consistent with previous studies [5][7].

These results suggest that linking the real world more directly with the mathematical world and promoting the development of the mental number line are crucial. As previous studies have indicated, metaphorical understanding, visualizing numbers, and physical movement are recommended to understand number concepts and to develop the mental number line [2][8][9]. The idea of the AR number line tool originated from the aforementioned reasons. However, we could not clarify how far tablet learning was accepted by Ugandan pupils because most of them had no experience in using iPads. The result of the subjective evaluation questionnaire revealed the possibility of tablet learning. Moreover, through the survey, we have identified some functional improvements in our applications.

In this study, we focused on mathematics education in relation to metaphors and developmental psychology to examine the cause of low achievement in Uganda. Furthermore, we identified the underdevelopment of the mental number line. We additionally determined that 15 pupils out of 60 could not understand the concept of a number line. Further study is needed to investigate these issues in greater detail. Moreover, we developed AR applications to address low achievement. However, the effects of the tools were not examined in this study.

V. CONCLUSION

In conclusion, we have clarified that the causes of low mathematics achievement are lack of learning with appropriate metaphors and the underdevelopment of mental number line. Furthermore, we have found no problems implementing tablet learning in Uganda. In the future study, we will conduct a survey to examine the detail of their understandings by interviews and the experiments using AR application for solving the causes and improving the mathematics achievement. In a future investigation beginning in August 2022, we will follow up on this issue.

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P02370

Development of Innovation-Based Learning and Teaching Model for Technology Education in Thailand 4.0 Era

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Abstract

This article presents the development of an innovation-based learning and teaching and learning model for technology education in the Thailand 4.0 era. The research conceptual framework is to study the goals of the development of Thailand 4.0, the development of teaching and learning models, and the expected competencies of graduates that the labor market needs. The research tools consisted of 1) the needs assessment form for analyzing the gap in innovative thinking competency, 2) the questionnaire assessing the quality of the DLAAP Innovation-based learning and teaching model for teaching technology and engineering. Research results were found that 1) systematic integration and linkage of knowledge, innovative product development, initiative, and innovative thinking must be

developed, 2) developed DLAAP innovative learning and teaching model is very appropriate (mean = 4.31 and S.D.=0.29) that can promote knowledge, skills, and attitudes to be able to work practicably in the industrial sector in Thailand 4.0 era.

Keywords— Innovation-based learning and teaching model, Technology education, Thailand 4.0 era

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Development of Innovation-Based Learning and Teaching Model for Technology Education in Thailand 4.0 Era

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Keywords: Innovation-based learning and teaching model, Technology education, Thailand 4.0 era

I. INTRODUCTION

Thailand recognizes the importance of technological changes that affect the economy and society. The government has set the policy "Thailand 4.0" that aims to drive and develop the country with technology and innovations created by themselves in Thailand as a "value-based economy" [1]. Efficient technology learning and use are important key performance indicators to improve the quality of the country's development. Therefore, the government has established guidelines for Education 4.0 era that encourages learners to have 21st century learning skills, which are 1) life and work skills, 2) learning and innovation skills, and 3) information, communication, and technology skills [2].

In addition, the National Education Act specifies guidelines for educational management [3] that,

- *emphasis on students being the most important,*
- *educational management must be based on the principle that all learners have the ability to learn and develop themselves,*
- *educational management model and process must encourage learners to develop naturally and to their full potential,*
- *learners will receive the suitability and maximum knowledge and benefit,*
- *providing opportunities for learners to play an important role and to participate in learning activities,*
- *using a variety of learning processes that will lead to self-learning and lifelong learning.*

For this reason, the new educational system has established a student-centered learning model, including the use of digital technology, allowing learners to participate in teaching and learning activities innovative learning management, promoting problem-solving skills, and designing and creating new things in technology and engineering. The research conceptual framework designed the following questions:

- *What are the necessary and expected competencies that graduates working in technology and engineering need?*
- *For learners to have such competencies, how should teachers manage learning and teaching activities?*

In this paper, the researcher explores the policy of education management in the 4.0 era, consisting of integrated teaching and learning, creative technology innovation development, creating a new body of knowledge from an old body of knowledge, and applying knowledge to the benefits. The main goal must be in line with the country's sustainable development policy in the Thailand 4.0 era, which focuses on producing people to create high-value innovations.

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II. Research Objectives

2.1 To analyze the gaps in innovative thinking competence of graduates to be a career in technology.

2.2 To develop innovation-based learning and teaching model for technology education.

2.3 To assess the quality of the appropriateness of the innovation-based teaching and learning model developed.

III. Teaching And Learning Model

Active learning is a learning process that encourages learners to link knowledge and apply skills for solving problems in the profession. The principle of active learning is the integration of varieties of teaching methods and techniques used to design lesson plans. Teachers organize learning activities that encourage students to participate in the class and promote interaction between learners and teachers. Active learning is instructional management that promotes student engagement, enhances relevance, and improves student motivation. This article presents and compares three learning models that are commonly used in the management of teaching technology and engineering. The details are as follows:

Project-based learning (PBL) [4] is experiential learning through systematic hands-on practice to give students the opportunity to have direct experience. From past research it was found that the project-based learning model focuses on student-centered learning and has integrated the concept of self-knowledge theory through the creation of works. This model can be used in teaching and learning in technology and engineering effectively because learners have participated in teaching and learning activities. It provides practical skills training that empowers learners to acquire learning skills that are relevant to the 21st century. As well as it can stimulate students to have creative thinking and product-making skills and encourage them to have higher academic achievement.

Research-based learning (RBL) [5] is learning that focuses on the learners' practice through scientific processes based on inquiry learning and the use of the research processes for teaching engineering appropriately. Research processes and research statistical data are used to manage learning activities. A variety of teaching materials have been created based on fidelity research results. Research-based learning can encourage students to have an analytical thinking process and solve engineering problems appropriately.

Innovation-based learning (IBL) [6] is a learning process that focuses on learners' learning through hands-on practice to be able in creating valuable work. From past research it was found that the results of the learning management were the innovation that emphasized value. Integrating knowledge, skills, and knowledge context including various factors where the influence of learning is applied to create innovation through the innovation development process. This learning model could promote collaborative learning, teamwork, research, and creativity in problem-solving. The created engineering and technology innovations are useful in both the education and industry sectors.

In summary, the comparison of the strengths of the three learning models can be shown in Table 1.

Table 1 Comparison of the strengths of the three learning models

Learning Issues/Strengths	PBL	RBL	IBL
1. Emphasis on learners-centering	X	X	X
2. Promote self-learning skills	X	X	X
3. Promote creative systematic /analytical thinking skills	X	X	X
4. Integration of teaching and learning sciences	X	X	X
5. Practice by studying, researching, experimenting, and creative working.	X	I	I
6. Generate new knowledge through scientific processes and educational/ engineering statistics	I	X	I
7. Extend the body of knowledge to increase economic value	I	I	X
8. Promote and respond to development of technology/basic education	X	I	I
9. Promote and respond to engineering/ science development	I	X	I
10. Promote and respond to development of industrial and social	I	I	X

Note: "X" means very important, "I" means medium importance, and "O" means low importance.

IV. Analysis Of Expected Competencies Of Innovation-Based Learning

The necessary and expected competency of learners for technology education in Thailand 4.0 age was analyzed, the Modified Priority Needs Index ($PNI_{modified}$) statistic [7] as shown in equation (1).

$$PNI_{modified} = (I - D) / D \quad (1)$$

When I means Important,
D means Degree of success.

Table 2 Analysis of expected competencies of innovation-based learning (N=7)

Expected Competency	D	I	$PNI_{Modified}$	Order
1. Research and analyze data/knowledge.	2.57	4.57	0.78	6
2. Communicate and work as a team.	2.57	4.71	0.83	5
3. Use technology and information systems.	3.29	4.71	0.43	8
4. Be a leader and take responsibility.	2.71	4.29	0.58	7
5. Self-study and lifelong education.	2.29	4.57	1	3
6. Create and develop valuable innovations.	2.29	4.71	1.06	2
7. Be creative and innovative thinking.	2.43	5.00	1.06	2
8. Perform tasks and solve professional problems.	2.71	5.00	0.84	4

Expected Competency	D	I	PNI _Modified	Order
9. Integrate and link knowledge systematically.	2.29	5.00	1.18	1
10. Create a prototype and applications.	2.57	4.71	0.83	5

The results of the data analysis showed the values indicating the level of necessity by using the modified PNI value for each item. The item with the higher modified PNI means that there is a higher level of need than the item with less modified PNI.

Table 2 presents the results of an analysis of learners' expected competency for technology education by using seven experts. It can be seen that the degree of success (D) was averaged between 2.29 -3.29, with the topic of the use of technology and information systems having the highest mean. The results of expected or important (I) competency were averaged between 4.29 and 5.00. The key competency topics were: being initiative and innovation, implementation and problem-solving in careers, and systems integration and link of knowledge (mean equaled to 5.00). The expected competencies that are urgently needed to develop, ranked from highest to lowest in three priorities consist of the integration and systematic linkage of knowledge ($PNI_{modified}$ = 1.18), the creation and development of innovations to add value, and having initiative and innovation ($PNI_{modified}$ = 1.06, self-study and lifelong ($PNI_{modified}$ = 1.00), respectively.

V. Design Of Innovation-Based Learning

The research process started from a study of Thailand 4.0 development goals in the fields of industry 4.0, economic system, education system, society, and learning in the 21st century. It was found that "the nature of teaching and learning must focus on the development of learners' competencies, linking creative knowledge to develop innovations". Then, developing a teaching and learning model that focuses on engaging learners in several learning activities, such as; identifying learning problems or topics, researching and studying theories/new knowledge body, creating a practice of work, etc. The expected competencies for learners include creativity skills, knowledge integration skills, practical and problem-solving skills, and etc. The conceptual framework is illustrated as follows, shown in Fig.1.

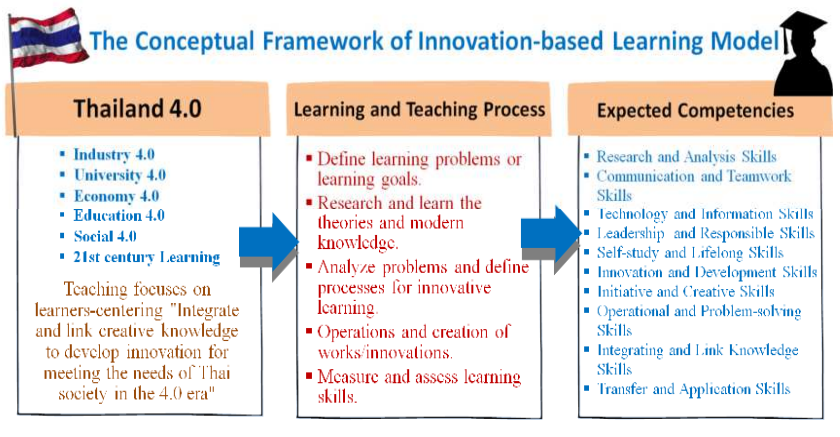

Fig. 1 The conceptual framework for developing an innovation-based learning model.

The innovation-based teaching and learning management can enhance learners' expected competencies, in this article, an innovation-based learning and teaching model was developed for technology education. This developed model focuses on developing innovative and creative skills, and integrating analytical and innovative thinking as a guideline for teaching and learning management called the DLAAP innovation-based learning and teaching model, as shown in Fig. 2.

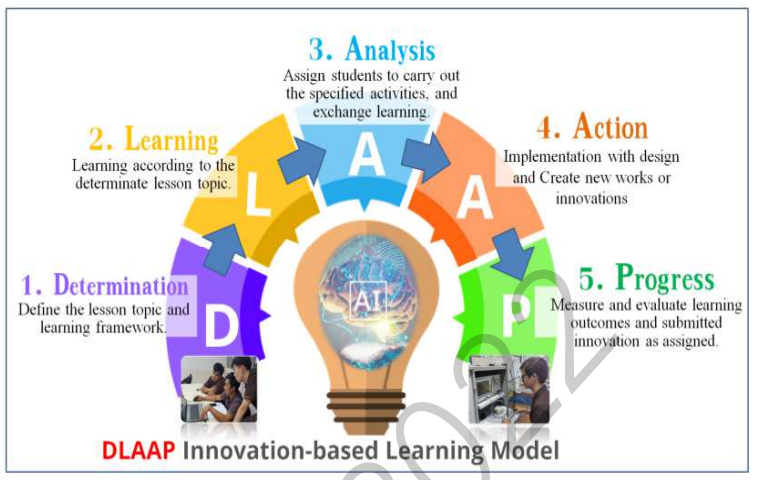

Fig. 2 Developed DLAAP innovation-based learning model

The DLAAP innovation-based learning and teaching model developed, consists of **5** steps as follows:

- Step 1: Determining the problem (D) is the determination of lesson topics and learning frameworks that teachers and learners consider and define together in order to get the information and contents that are truly needed.
- Step 2: Learning (L) is the learning process according to the specified lesson topic through an integrated teaching system that uses teaching media, such as simulation programs, real media and demonstration packages, laboratory, etc.
- Step 3: Analysis (A) is the process of assigning learners to perform the activities specified in the worksheet that requires further research. There is an exchange of knowledge with group members.
- Step 4: Action (A) is the process of performing tasks that are carried out as a group activity by designing and creating modern work pieces or innovations.
- Step 5: Evaluation (P) is to measure and evaluate the learning outcomes of learners through the diverse exam systems and submitted innovations as assigned.

VI. Result of Teaching and Learning Model

The quality assessment of the suitability of the DLAAP Innovation-based learning and teaching model by using 7 experts was shown in Table 3. In considering the assessment of the suitability of the DLAAP innovation-based learning and teaching model, it was found that the developed DLAAP learning and teaching model was at a high level (mean = 4.31 and S.D. = 0.29). The important issue is

the teaching and learning process including promoting innovation and technology skills that are appropriate at the highest level.

Table 3 The results of the quality assessment of the teaching and learning model (N=7)

Topics/Issue	Appropriate Level		
	Mean	S.D.	Interpret
1. Supporting innovative learning.	4.29	0.49	High
2. The teaching and learning process is appropriate.	4.57	0.53	Highest
3. Methods for measuring and evaluating according to actual conditions.	4.00	0.58	High
4. Promote participation in teaching activities.	4.29	0.49	High
5. Promote innovation and technology.	4.71	0.49	Highest
6. Promote innovative thinking processes.	4.29	0.49	High
7. Encourage knowledge, skills and attitudes.	4.29	0.49	High
8. Encourage self-learning and lifelong learning.	4.14	0.69	High
9. Promote problem-solving skills and creativity.	4.29	0.76	High
10. Can be applied in technology education.	4.29	0.49	High
Overall Score	4.31	0.29	High

VII. CONCLUSIONS

This research paper has presented the development of the DLAAP innovation-based learning and teaching model for technology education in the Thailand 4.0 era. The DLAAP learning and teaching model can promote innovative creativity skills. After analyzing the gaps in expected competencies of graduates pursuing a career in technology, it was found that the necessary needs that should be developed are as follows: systematic integration and linking of knowledge, developing innovations to add value, and having initiative and innovation. As more as the self-study and lifelong learning skills is an important competency that can encourage students to develop innovations and new technologies. For evaluating the appropriateness of the DLAAP innovation-based learning and teaching model, it was found that the developed learning model was found to be highly appropriate (mean = 4.31 and S.D.=0.29). Therefore, the DLAAP innovation-based learning and teaching model is capable of effectively teaching and learning in technology and engineering.

Suggestions for research development to have academic quality, it is necessary to redesign appropriate teaching and learning as follows:

- Learners' activities, learners must be involved in the learning process at every learning process. Learning activities must encourage learners to have an analytical thinking process, work planning, conducting learning activities troubleshooting, and feedback to drive expected learning outcomes.
- Teaching materials, teachers must provide and create a sufficient number and variety of learning materials. Quality media must be able to motivate and encourage learners to be exciting about learning and towards the expected learning outcomes, as shown in Fig.3.

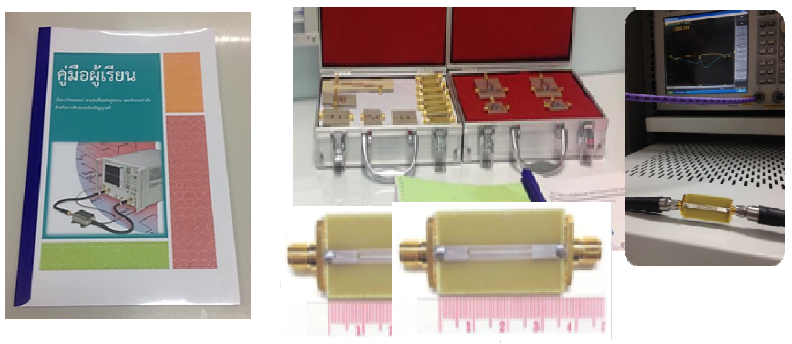

Fig. 3 The variety of learning materials in teaching

- Measurement and evaluation, the design of measurement and evaluation methods shall consist of methods for measuring behavioral objectives, multiple-choice and subjective evaluation methods, and measuring learning achievement directed towards expected learning outcomes.

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P02350

Learning Management using Lessons Online in Pulse and Switching Circuits Subject for Vocational Certificate Students

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Abstract

This purpose of this research was: 1) to create lessons online using google site based on the ADDIE model in pulse and switching circuits subject, 2) to test efficiency of the lessons online using google site in pulse and switching circuits subject, 3) to compare the learning achievement before and after learning with the developed lessons online and 4) to assess satisfaction of student with lessons online using google site based in pulse and switching circuits subject. The Sample groups of the research were 32 the first-year students with a vocational certificate in the Department of Electronic Technical, Nakhonnayok Technical College, research tools include lesson plan, online lesson, achievement test and students' satisfaction form. The research results shown that 1) the efficiency of the developed learning management using lessons online had the efficient of 76.92/75.23 higher than the 75/75 criteria, 2) The learning achievement of the learners was significantly higher than

before learn at the .05 level. and 4) the students had a high level of satisfaction on learning management using lessons online (mean is equal to 4.42 and standard deviation is equal to 0.16).

Keywords— ADDIE model, Google Site, Lessons Online, Yager, Vocational Certificate

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Learning Management using Lessons Online in Pulse and Switching Circuits Subject for Vocational Certificate Students

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I. INTRODUCTION

Learning and teaching in the twenty-first century has focused on the use of information technology and change the learning process from passive Learning to active Learning that focuses on learners (Student Center) in accordance with the National Education Act B.E.1999 and Amendments (Second National Education Act B.E.2002),Chapter 4, Section 22 that "Education must be based on the belief that all students are capable of learning and self-development and should be prioritized. The teaching-learning process shall aim at helping the learners to develop themselves at their own speed and to the best of their potentiality" and Chapter 4, Section 24(6) that "Individuals must be able to study at all times and in all locations in order to develop learners to their full potential."[1] Therefore, public and private educational institutions respond to such policies and develop teaching and learning management through information systems.

Due to the COVID-19 is now causing a pandemic, educational institutions are unable to deliver conventional teaching and learning and must adapt their teaching styles to include online learning in order for students to study continually. Online teaching has elements such as teachers, learners, content, learning materials, and learning resources. Learning management process communication system Information technology network systems, etc. [2] Technology can increase the efficiency of teaching and learning. by using online media such as google site, e- learning etc. Google site is an electronic teaching and learning management that uses internet technology and web technology as the main channel to communicate with learners, schedule teaching activities, digital content presentation, interactive communication and measurement and evaluate [3] enables students should be able to access learning from any location, anytime and continual self-learning. The MIAP Model learning management process is a student-centered process. and encourage learners to gain knowledge skills clearly. The learning process consists of 4 steps: Motivation, Information, Application and Progress. [4]

Therefore, this research has developed the teaching and learning management through online lessons with google site in the Pulse and Switching Circuits Subject for vocational certificate student to encourage learners to have knowledge, skills and higher learning achievement.

II. RESEARCH OBJECTIVES

1) To create lessons online using google site based on the ADDIE model in pulse and switching circuits subject.

2) To test efficiency of the lessons online using google site in pulse and switching circuits subject.

3) To compare the learning achievement before and after learning with the developed lessons online.

4) To assess satisfaction of student with lessons online using google site based in pulse and switching circuits subject.

III. RESEARCH HYPOTHESIS

1) The developed lessons online using google site was efficiency according to 75/75 criteria.

2) The learning achievement of the learners was significantly higher than before learn at the .05 level.

3) The students' satisfaction in the learning management using lessons online at a high level.

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IV. LEARNING THEORY

A. Online Lessons

Online learning is another educational innovation. which can change the way of studying in the old way to be a new learning that uses technology to help teach In addition, another meaning means distance learning, web learning as well. The main thing is online lessons including of electronic lessons through the Internet network developed as teaching materials by presenting the content of any subject Learners are able to study the content on their own and there is interaction between teachers and learners in order to effectively achieve the required learning outcomes.

Principles for designing online lessons include of Easy learn, Easy use, Efficient to use and Few errors.

B. ADDIE Model

Training developers and instructional designers use the ADDIE model to plan and construct effective learning experiences.

"ADDIE" [5] stands for Analyze, Design, Develop, Implement, and Evaluate.

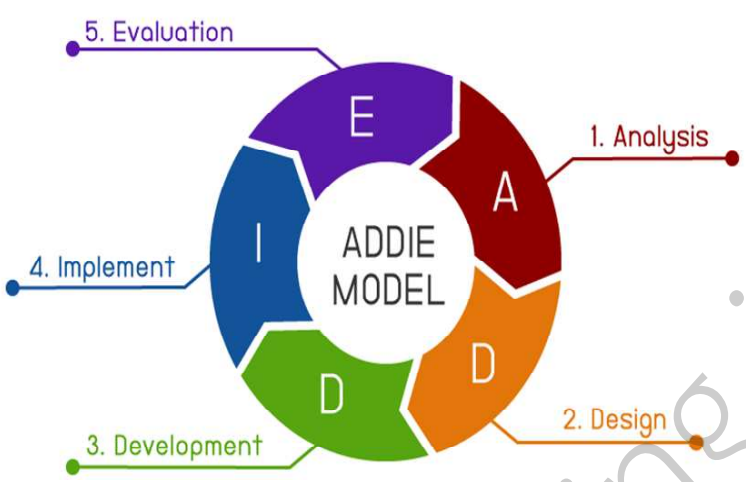

Fig.1. the ADDIE model

V. IMPLEMENTATION

This research was experimental research with the purposive sampling to validate the efficiency of the learning management using lessons online. The following were the research methods:

A. Defining a sample group

The sample group of this study was 32 students for first-year vocational certificate level in the Department of Electronic Technical at Nakhonnayok Technical College that enrolled in the pulse and switching circuits subject in semester 2, academic year 2021.

B. Defining a sample group

Research was developed using the ADDIE model with the with the development process as shown in Figure 1.

The analyze (A) steps are as follows.

1) Analyze content of the pulse and switching circuits subject

2) Analyze achievement test using 4-multiple choice tests

3) Analysis contextual the development of online lesson using MIAP Model

The design (D) steps are as follows.

1) Design a lesson plan for pulse and switching circuits subject consist of course description, job sheet, operation sheet, evaluation sheet, test sheet and test solution sheet.

2) Design the online lesson according to the MIAP learning process.

3) Design teaching and learning processes using the MIAP Model that consist of motivation information application and progress.

4) Design the measurement and evaluation of achievement that is consistent with the behavioral objectives.

The Development (D) steps is online lessons developed using google site that the 1) content parts are presented in the documents form and video teaching, 2) student data collection part developed on google site.

The Implementation (I) steps, the researcher applied the online lessons try out with sample group and collect data that is pre-test, post-test, exercises, achievement test and students' satisfaction form.

The Evaluation (E) steps, analyze the results of student's the online lessons trial using statistical values and conclusions.

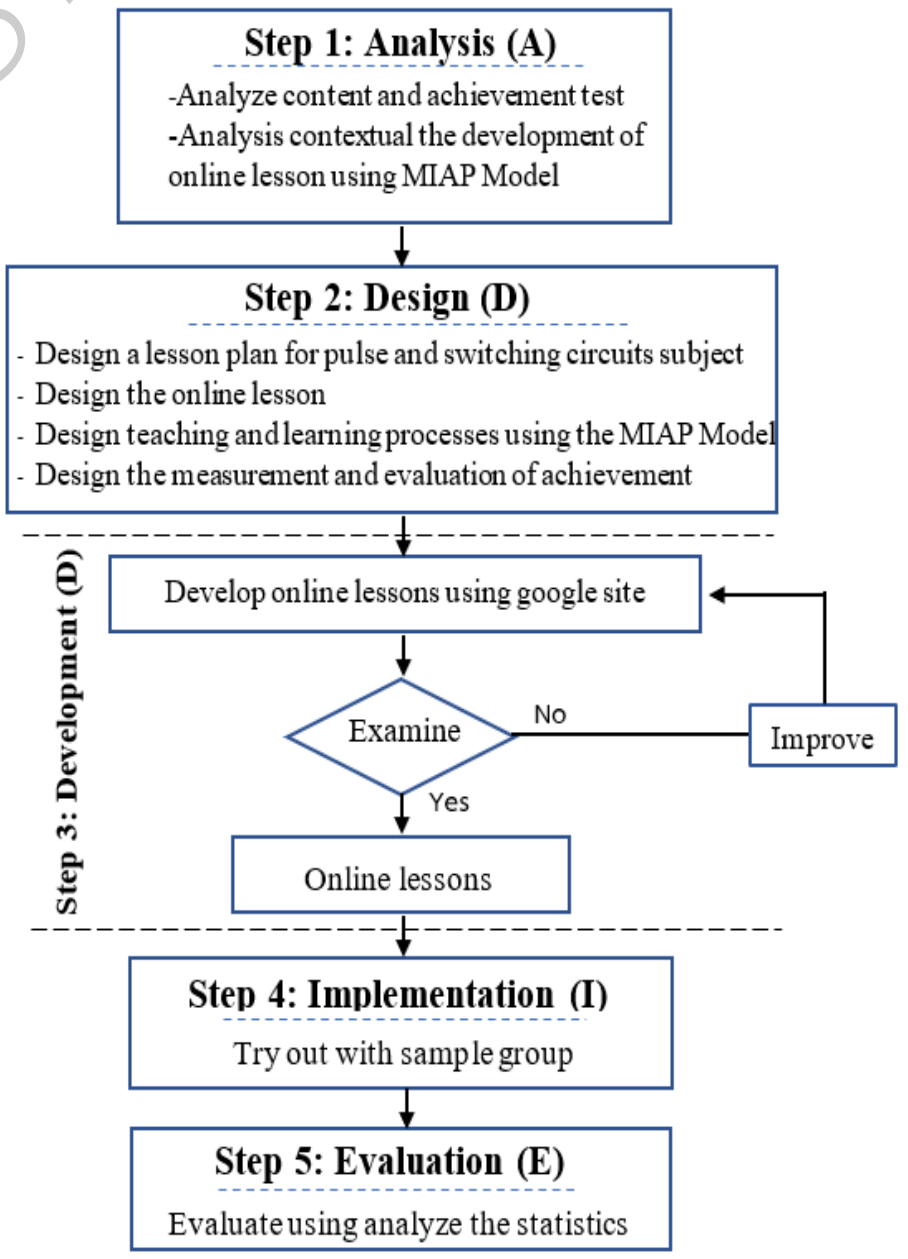

Fig.2. Development of research tools according to the ADDIE model

C. Finding the quality of research tools

The quality of the tools in this research was assessed using a 5-level questionnaire by five professionals with experience in teaching and researching on electronics and online media. The questions were as follows: 1) Teaching and Learning Activities. 2) Style of lessons online and 3) Measurement and evaluation found that the research tool was appropriate at a high level (mean =4.48)

D. Data collection in research

The experimental use of the developed research tools that try out with a sample group of 32 students in the Department of electronic technical for vocational certificate student who enrolled in the academic year 2/2564 in the pulse and switching circuits subject consisting of 13 topic as follows: 1) Electrical signal shape and parameter 2) Attenuate circuit 3) Integrator and differentiator 4) Clipper 5) Clamper 6) Transistor switch 7) Schmitt trigger 8) Astable multivibrator 9) Monostable multivibrator 10) Bistable multi vibrator 11) Logic gate and oscillator 12) Flip-Flop 13) Synchronize and time diagram. This research used a method to select a purposive sampling according to actual registration that organize teaching and learning with the online lessons using google site. Students take a pre-test, after that at the end of each topic of learn, instructors measure learning process achievement (E1) and then operate teaching and learning activities for all topic, instructors tested using 40-item achievement test (E2). The researcher collect the data and used the data for statistical analysis according to the hypothesis and conclusions.

VI. RESEARCH RESULTS

This research was to develop learning management using online lessons based on the ADDIE model in pulse and switching circuits subject for vocational certificate student, the results were analyzed statistically such as average, standard deviation and t–test dependent formula, which could be summarized into 4 parts as follows:

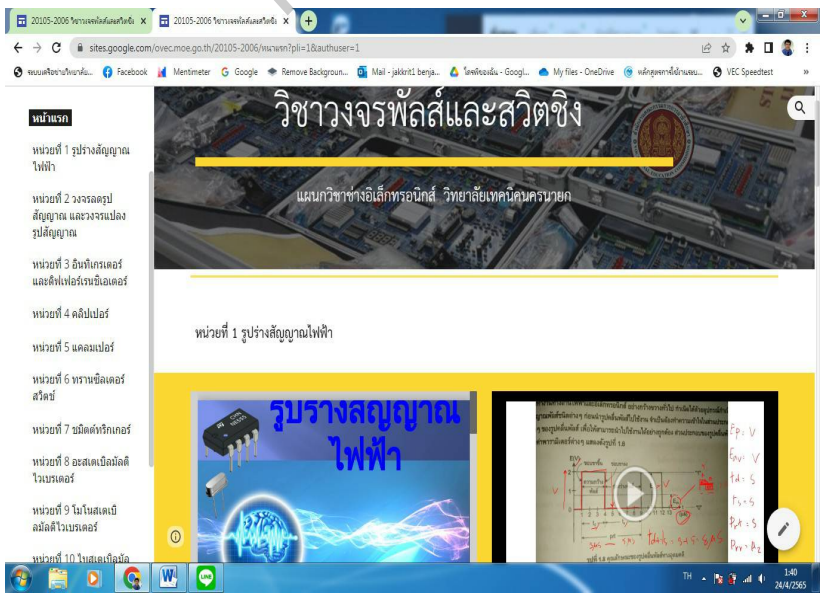

Fig.3. Online lessons using google site

A. Results of developed the online lessons

The researcher developed an online lessons using the MIAP learning process in the subject of pulse and switching circuits as shown in Figure 3.

B. The efficiency results of developed online lessons.

The results of the analysis efficiency of the learning management using lessons online in pulse and switching circuits subject for vocational certificate student as shown in table I, which has learned on pulse and switching circuits subject in 13 topics by collecting scores during each learning topic and scores the results at the end of the learning. The efficiency E1/E2 is equal to 76.92/75.23, which was higher than the specified criterion of 75/75 (according to the research's hypothesis).

TABLE I. EFFICIENCY OF DEVELOPED ONLINE LESSONS (N=32)

Quiz set	Full score	Average score	Percentage
Efficiency of process(E1)	60	46.16	76.92
Efficiency of product(E2)	40	30.09	75.23

C. Analysis results of students' progress.

The instructors will have students take a pre-test of 40 items and collect the data for comparison with the scores from the achievement test by analyzing learning progress using the statistical value of t-test. Table II shows the results.

TABLE II. THE COMPARISON OF STUDENTS' LEARNING PROGRESS (N=32)

Test	t-test for equality of means				
	Mean	SD.	df	t	Sig. (1-tailed)
Pre-test	13.34	3.39	31	36.94	0.0000
Post-test	30.09	3.86			

**Statistical significance at .05*

From table II, the results of an analysis of learn progress by comparing the results of pre-test and post-tests, found that the average score of the students' pre-test was 13.34 and the mean score after studying was 30.09 (full score = 40 points), the calculated t-value was 36.94 at the statistical significance level of .05 and df = 31. Therefore, learning management using lessons online of the students were significantly higher than before the learn at .05 level.

D. Assessment results of students' satisfaction

The assessment the satisfaction of 32 students who have through the learning management based on lessons online using the 1-5 Likert's rating scale questionnaire. The following topics are used to assess satisfaction with the learning process: 1) Teaching and Learning Activities.

2) Style of lessons online and 3) Measurement and evaluation, as shown in table III

TABLE III. THE SATISFACTION OF TRAINEES (N=32)

Evaluated topics	$\overline{X}$	S.D.	Interpret
Teaching and Learning Activities			
1.Teaching and learning activities are clear and sufficient.	4.47	0.51	high
2.Encourage students to learn by themselves	4.38	0.55	high
3.Learning management encourages learners to knowledge and skills.	4.72	0.58	highest
4.Counseling/facilitation of teachers	4.84	0.37	highest
	4.60	0.25	highest
Style of lessons online			
1. The picture/audio corresponds to the lesson online.	4.31	0.59	high
2. Language accuracy	4.34	0.60	high
3. Learning resources is various	4.69	0.54	highest
4. The design of online lessons is modern	4.53	0.67	highest
	4.47	0.35	high
Measurement and Evaluation			
1. Measurement and evaluation methods are consistent with teaching and learning management.	4.00	0.76	high
2. Measurement methods can be used to assess learning outcomes.	4.19	0.47	high
3. The evaluation criteria are clear and appropriate.	3.91	0.69	high
4. The measurement method can be used to collect data based on authentic Learning.	4.59	0.61	highest
	4.17	0.34	high
Average	**4.42**	**0.16**	**high**

From Table III, it be seen that the students' satisfaction with the learning management using lessons online in pulse and switching circuits subject at a high level. The mean was 4.42 and the standard deviation was 0.16, the students were most satisfied with the teaching and learning management (mean = 4.60 and S.D.=0.25), style of lessons online (mean=4.47 and S.D.=0.35) and measurement and evaluation (mean=4.17 and S.D.=0.34), respectively.

VII. CONCLUSION

The result of development and finding the efficiency of teaching and learning management through online lessons with google site, Pulse and Switching Circuits Subject was 76.92 / 75.23, which Higher than the specified standard (75/75) because the researcher has designed online lessons with google sites that use the MIAP Model learning process as a clear step-by-step process. There are various learning sources. There is a video demonstration that focuses on quality practice. As a result, students have higher academic achievement. consistent with Laddawan and Buncha [6], they are development of web-based instruction using google site based on the constructivist theory entitled "The principles of making computer-based project". found that the efficiency of the developed online lessons was 86.13/87.83, which is higher than the benchmark 85/85. That mean the developed online lessons can encourage learners to acquire knowledge higher academic skills and achievement. Comparison of learning achievement before and after learning with online lessons found that it was in accordance with the hypothesis was higher than before significantly at .05 because online lessons have a quality and be interesting for students to learn and explore, This is consistent with the research of Supattra, Thiyaporn and Suwanna [7].

The learners' satisfaction were at a high level, which is consistent with the research of Nawattanachot, Sanchai and Natthaphon [8] found that the students' satisfaction was at the highest level (mean = 4.57 and SD= 0.55)

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S-STEM: Summer Bridge Program for, Academic Improvements, and Long-term Persistent Success

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Abstract

Over the past fifty years, fifty percent of students who enter colleges do not finish their four-year degree, because a substantial number of them are not prepared for college. Universities are employing innovative approaches and pedagogies aimed at accelerating the learning process and academic ability of freshman students. One popular approach is summer bridge programs (SBPs) that provide foundational knowledge for core college courses and a roadmap for successful college life. Typically, the bridge programs happen during the summer before a student's first year and are considered a bridge from high school to college. This paper reviews recent summer bridge programs at diverse teaching institutes, private, public, and open access educational institutes. Additionally, we analyzed our SMART-STEM (S-STEM) summer bridge program organized at Capitol Technology University for academic improvements and long-

term persistent success in careers beyond college. The results of our three S-STEM projects indicate that there is a clear improvement in student retention and graduation rate. The three different cohorts achieved higher retention rates (73 to 91 %) than previous STEM majors (56%).

Keywords—component, formatting, style, styling, insert

S-STEM: Summer Bridge Program for, Academic Improvements, and Long-term Persistent Success

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Keywords—component, formatting, style, styling, insert

I. INTRODUCTION

According to the National Center for Education Statistics (NCES), in 2019, 63% of students started in 2013 and completed graduation in 2019. These first-time full-time students took 6-years to graduate. Also, students who started at public, private nonprofit, and private for-profit graduated at 62 percent, 68 percent, and 26 percent rates respectively. Furthermore, the overall 6-years to graduate rate was 60 percent for males and 66 percent for females. In public institutes, the graduation rate for females was higher (65 vs. 59 percent) than the private nonprofit female graduation rate. However, at private for-profit institutions, males had a higher 6-year graduation rate than females (28 vs. 25 percent) [1]. According to GoCollege 2019, the high drop-out rate was attributed to personal and external factors; including academic unpreparedness, homesickness, lack of fit into the college, personal or family, and financial issues [2]. According to Tinto, [3] students depart higher education without earning a degree because of the nature and quality of their interactions with the college or university, academic failure, and failure to integrate socially and intellectually with the culture of the university. According to researchers [4,5,6 and 7], the Bridge program is more critical for students' success from traditionally disadvantaged backgrounds. Weuffen [8] indicates that a foremost reason for withdrawal is attributed to personal lack of use, or insufficient, college inner supportive plans and procedures. The goal of these summer bridge programs is to address the amalgamation of underprivileged students to the academic and social aspects of the college atmosphere, set expectations, inspire, and increase retention to graduation [9].

The S-STEM summer bridge program aims in developing a transdisciplinary, sustainable, and scalable approach to train a workforce skilled in research and application of smart computing S-STEM. The program can fulfill a need in terms of providing undergraduate/graduate instructional resources in the multidisciplinary area of Computer Science. Besides, this program could prepare a trained research workforce to cater to industry, academia, and government. The S-STEM scholarship has supported the transfer from an associate degree program to a baccalaureate program or transferring from a baccalaureate to a graduate program. The program was focused on providing resources such as faculty one-on-one mentorship, career counseling, and placement services. The characteristics and academic needs of the students to be served include low-income, first-generation students, disadvantaged and underserved students. Students living in poverty often have fewer resources to help them at home to study, complete homework, or engage in activities to help them to succeed [10]. A lot of impoverished families do not have access to computers, high-speed internet, or other resources to help students outside of school. Many times, parents of these families work long hours or multiple jobs to provide for their families. Data shows that poverty negatively impacts students beyond K-12 education. The SMART Program is focused on serving these low-income students as well as the needs of our country[10].

The following is how the rest of the paper is structured: The introduction is covered in section I, and the literature review is covered in section II. Then, section III describes S-STEM: Summer Bridge Program. Section IV describes the result from prior grants. Section V explains the implementation of research.

Section VI describes the result and analysis of S-STEM grants Finally, section VII concludes the research paper.

II. LITERATURE REVIEW

The President's Council of Advisors on Science and Technology warned in a 2012 report that the U.S. faces a shortage of 1 million workers in STEM occupations over the next decade and suggested that retention of students in the first two years of STEM study is the most efficient way to eliminate this shortage. Despite excellent employment opportunities, attrition in engineering and technology degree programs is high, nationwide and at Capitol. Only about 40% of students who enter college intending to earn a degree in engineering complete a B.S. in a STEM field, and for students intending to major in computer science, only 24% complete the degree [11]. Nationally, STEM attrition is higher in the first two years of college, and higher for underrepresented minorities, women, and disadvantaged (low income) students [12].

Attrition in the first two years is high at Capitol: two of three first-time, full-time students enroll for a junior year, and only one in two completes a B.S. in six years. This research sought to retain participants past the critical two-year attrition point with "high-impact" practices including a summer bridge program, faculty mentoring, cohort bonding activities, and peer mentoring, all of which have been shown to help reduce attrition in STEM disciplines [13,14,15,16]

These activities are particularly effective for first-generation students and underrepresented minorities when combined with financial assistance to remove the distractions of part-time off-campus jobs unrelated to STEM study [17,18,19]. All Capitol Scholars Program participants have high financial needs, which typically indicates a disadvantaged socioeconomic background. Many are first-generation college students who do not know any college-educated STEM professionals. They know extraordinarily little about professional workplaces and STEM careers without these role models. As their coursework becomes more difficult, their commitment to STEM study may start to fade in their sophomore year, and additional interventions are necessary to encourage persistence in STEM [20,21,22].

Researchers have proposed different teaching pedagogy and innovative curriculum to enhance the teaching-learning experience [23,24]. As part of this research, Capitol plans to focus on the latter: preparing students for an internship at the end of their sophomore year. This preparation will include a coordinated series of activities starting with an online career skills course for rising Sophomores and continuing throughout the sophomore year with a structured faculty mentoring program and a series of workshops that take students through the steps leading up to the attainment of an internship. To assess the effectiveness of this approach, a research study sought a correlation between these career-focused faculty mentoring and additional activities and students' persistence.

III. S-STEM BRIDGE PROGRAM

Capitol Technology University (CapTech) proposes the development of S-STEM, a transdisciplinary, sustainable, and scalable approach to training a workforce skilled in research and application of cybersecurity. The project fills a need by providing undergraduate/ graduate instructional resources in the multidisciplinary area of Cyber as well as preparing a trained research workforce to cater to industry, academia, and government. S-STEM a hands-on educational approach aims to broaden access to skills necessary for developing and using software-based cyber defense tools with classical and emerging architectures to address questions in the cyber-physical world. Another goal was to foster a sustainable community of contributors in the long term (beyond the initial group of learners) by catalyzing grassroots educational efforts.

S-STEM accomplishes these goals by (i) exposing undergraduate/graduate students to core computational hands-on that prepares them to address technical questions in a variety of contexts that require the development and application of large scale cyber defense systems, data-driven, classical, and quantum cryptography ; (ii) establishing 6-months and nine months internship for graduate students to gain practical experience in applying these skills to domain-specific problems; (iii) supporting students via hands-on education in best cyber practices and access to mentorship to create peer-reviewed, open-source tutorials, and tools. The program engages the enthusiastic cyber community of trainers and experts by leveraging existing hands-on learning modules to prepare students, and consulting with the community via an advisory board and needs assessment to draw on their expertise in developing impactful, widely accessible educational materials during every stage of the project.

IV. RESULT FROM S-STEM SUMMER BRIDGE PROGRAM AT CAPITOL TECHNOLOGY UNIVERSITY

Before the start of their freshman year, each cohort will attend a three-week residential summer bridge program that immerses them in an intensive environment where they learn strategies for success in their college work, complete one or two Freshman courses, and visit an engineering or cybersecurity organization each week. Room and board will be provided. S-STEM has been refined each year and student surveys have shown that S-STEM consistently achieves its objectives of cohort bonding, improvements in study skills, and a confidence-building "jump start" on introductory coursework. CISS was modeled after the NASA Pre-College Minority Engineering Program (NASA PREP), a six-week summer bridge program that Capitol College developed for disadvantaged students and offered from 1992 through 2006 with NASA funding. NASA PREP participants achieved higher college GPAs and retention rates compared to their peers.

Capitol Technology University proposes to continue to offer and improve our existing S-STEM-funded Capitol Scholars Program (CSP). The previous grant-supported first-year students entered in the fall of 2018, 2019, and 2020. Scholarships and student support activities will be provided for 30 academically talented low-income students during their first

two years of study in engineering, computer science, cybersecurity, or engineering technology. The improved program will include a series of career focus activities for sophomores that will culminate in an internship experience during the summer between the sophomore and junior years.

Capitol Technology University (previously Capitol College before Oct. 2014) received three NSF S-STEM grants. The first two funded the Capitol Scholars Program, which supported students during their Freshman and Sophomore years. The third grant-supported community college transfer enrolls as Juniors.

A. First S-STEM Grant (DUE-0806985)

Capitol received its first S-STEM grant in Sept. 2008. This five-year grant funded the Capitol Scholars Program for academically talented low-income students in engineering, computer science, and engineering technology. The program's goal was to increase the retention rate for participants during the critical first two years of college, from 56 percent (for students who entered in 2004) to more than 70 percent. S-STEM scholarships of $10,000 were awarded to first-time first-year students. Three cohorts of nine students each entered Capitol in the Fall semesters of 2009, 2010, and 2011.

Grant money, supplemented by institutional funds, was used to provide academic support and enrichment activities. During the summer before their first semester, each cohort attended a three-week bridge program. During their first semester, the cohorts were enrolled as a group in a section of the Freshman Seminar course. Enrichment and mentoring activities included faculty-led workshops and field trips. The academic progress of each student was closely monitored, and individuals received counseling and additional assistance, including tutoring, when needed. These program elements provided the extra support to get the students past the critical two-year point.

Table 1: Results of First S-STEM Grant

Cohort	First Yr. Cohort Enrolled	No. Recip-ients[1]	Annual Scholarship Amt.	No. Past Attrition Point[2]	% Past Attrition Point[2]	No. B.S. Grads	% B.S. Grads[3]	No. Stopped attending
1	2009-10	9	$10,000	8	91%	6	72%	3
2	2010-11	12	$10,000	9	73%	6	50%	6
3	2011-12	9	$10,000	8	80%	8	89%	1

[1] Includes substitutions.

[2] The attrition point for the first two S-STEM grants is the successful completion of the first two years of study.

Quantitative Results—All three CSP cohorts achieved higher retention rates (73 to 91 %) than previous STEM majors (56%). Data for each cohort are shown in Table 1.

The Capital Scholars Program raised Capitol's profile at area high schools, and publicity about the scholarships have helped Capitol recruit additional high-ability students, thus raising the overall academic qualifications of each first-year class. During the grant period, the average high school GPA of incoming first-year students increased from 2.7 to 3.3 and the average SAT of incoming freshmen increased from 930 to 1020.

Qualitative Results—Surveys of the scholarship recipients and observations by the faculty indicated that the summer bridge program, which brought each cohort to campus for three weeks of academic work and college preparation exercises, achieved the goals of preparing students for college-level courses and encouraging cohort bonding. The faculty-led workshops and other activities during the academic year were also well-received by the students, who expressed appreciation for the opportunities to interact with their professors outside the classroom.

An unexpected benefit of the Capitol Scholars Program was the participants' elevated level of involvement in extracurricular activities. Relieved of the need to hold off-campus jobs to pay for their education, many of the scholarship recipients took on leadership roles in Capitol's student organizations and clubs, and they energized campus life outside the classrooms and labs.

B. Second S-STEM Grant (DUE-1259933)

Capitol received a second five-year S-STEM grant in Sept. 2013 to continue the Capitol Scholars Program. This grant provided support during the first two years of college for 33 students in engineering, engineering technology, computer science, and information technology fields, to increase the retention rate from the First year to Junior year to more than 80 percent. The research project was built on the first S-STEM grant. The first cohort's 11 students enrolled as seniors in Spring 2018. The second cohort of 11 students started their junior year and 100% of the students enrolled in Spring 2018. The third cohort enrolled in Spring 2018 (100% one retention to the second year and 82% continued into the second semester of the second year). S-STEM scholarships were $8,300 that year.

Table2: Results of Second S-STEM Grant

Cohort	First Yr. Cohort Enrolled	No. Recip-ients[1]	Annual Scholarship Amt.	No. Past Attrition Point[2]	% Past Attrition Point[1]	No. B.S. Grads	% B.S. Grads	No. Stopped attending
1	2014	11	$8,300	9	82%	7	64%	3
2	2015	11	$8,300	11	100%	10	100%	0
3	2016	12	$8,300	11	92%	7	64%	3

[1] The attrition point for the first two S-STEM grants was the successful completion of the first two years of study.
[2] The first degrees for the 2015 cohort were awarded in May 2019 and the first degrees for the 2016 cohort were awarded in May 2020.

Based on the first two cohorts the percent of students who persisted beyond the identified attrition point of the second year was expected to be higher than achieved during the first S-STEM-funded program. Additionally, students in this program are persisted at a higher rate than students in Capitol's general population. For the 2014 cohort S-STEM, students persisted to their third year at a rate of 82% compared to 67% for the general population. Additionally, the 2014 cohort of S-STEM Students' four-year graduation rate was 54% compared to 25% for the general population. The 2015 cohort of S-STEM students persisted to their fourth year at a rate of 100% compared to 55% for the general population. The 2016 cohort of S-STEM students persisted to their third year at a rate of 92% compared to 65% for the general population.

C. Third S-STEM Grant (DUE-1458780)

Capitol received a third five-year S-STEM grant with a start date in August 2015 to implement the Cyber Transfer Student Program (CTSP). This grant provided two-year S-STEM scholarships to three cohorts of incoming junior transfer students in the Cyber and Information Security (CYS) Department. Capitol recruited a total of 26 students into three cohorts (Fall 2016, Fall 2017, and Fall 2018). The students who are recruited to this program were place-bound and completed their degree via synchronous online distance education. Place-bound students are limited in their educational options because work or family commitments make it difficult or impossible to move to a university making distance education an ideal way to matriculate into a field not offered within their community. The university learned two lessons during the first year of the first cohort. The first lesson was that not all students who have earned an Associate of Applied Science have completed a mathematics course that fulfills the prerequisite for Intermediate Algebra (MA114). The university had not anticipated offering developmental mathematics courses for students in the online Cyber Transfer Student program. The academic leadership identified faculty to teach appropriate developmental mathematics courses online, however, the decision was made to screen future cohorts for mathematics readiness before selection. The second lesson learned was related to the preferred course load of adult learners. Many are completing their degree program while continuing to work full time and manage family or community commitments. A 15-credit course load is challenging for these students. As a result, many take 12 credits and end up extending their course load beyond the two years originally anticipated for completion.

Table3: Results of Third S-STEM Grant

Cohort	First Yr Cohort Enrolled	No. Recipients	Annual Scholarship Amt.	No. Past Attrition Point[1]	% Past Attrition Point	No. B.S. Grads	% B.S. Grads	No. Stopped attending
1	2016	5	$10,000	2	40%	2	40%	3
2	2017	9	$10,000	5	55%	5	55%	4
3	2018	11	$10,000	6	55%	6	55%	3

[2] The attrition point is graduation
The 2018 cohort is anticipated to begin graduating in May 2019.

V. Research Study

A. Research Plan

After an initial planning and recruitment year, the Capitol Scholars Program enrolled a cohort of 10 Freshmen each fall for three years, 2018, 2019, and 2020. Students applying as Freshmen for full-time study in seven Bachelor of Science programs in the Astronautical Engineering Dept., Engineering Dept., Computer Science Dept., and Cyber and Information Security Dept. were eligible to apply. The seven academic majors are:

Computer Science (CS)
Cyber and Information Security (CYS)
Astronautical Engineering (AE)
Electrical Engineering (EE)
Computer Engineering (CE)
Computer Engineering Technology (CET)
Electronics Engineering Technology (EET)

Students were required to submit a FAFSA for each year to verify eligibility. Students were determined to be financially eligible if their unmet need is $10,000 or more (cost of attendance – estimated family contribution (EFC) > $10,000) during their freshman and sophomore years. students who completed in 2019 show the graduation rate of three types of educational institutions.

A. Meeting S-STEM Goals: The Capital Scholars Program supports the S-STEM program goals by focusing on strategies that promote success during the first two years of college for low-income academically talented students pursuing bachelor's degrees in STEM fields; by studying the effects of career-focused activities on participant's self-efficacy in STEM study; and by sharing the results of the program and research study.
Attrition Milestone—Completing the first two years toward a bachelor's degree in a STEM field has been identified as a period of high attrition at Capitol Technology University. Typically, 30% to 40% of students stop attending by the junior year. Historically, 80 percent of Capitol students who start their third year continue to degree completion.
B. Demographics: Enrollment demographics for STEM disciplines Enrollment demographics for the institution and individual disciplines in the proposed project are shown in Table 2. Enrollment and retention data are for Fall 2014 (one-year retention rate is for first-time full-time students entering in Fall 2013, two-year is for students entering in Fall 2012). The B.S. total is the number of degrees awarded during the 2014-15 academic year. Graduation rate data is for all first-time full-time students entering in Fall 2009; the completion rate is 55% for the 2009 CSP cohort. Estimates of one-year retention rates, two-year retention rates, and B.S. completion rates are 85%, 75%, and 55%, across all disciplines.

VI. RESEARCH OUTCOME & ANALYSIS

A student who maintained eligibility received S STEM scholarships of up to $10,000 per year, plus additional institutional aid up to full tuition. In addition to receiving critically needed financial support, students participated in a series of Capitol Scholars Program support activities, as described in S-STEM Student Support Services and Programs, p. 11.
Support After the Scholarship Period—After the two-year S-STEM scholarship period ended for each cohort, the university continued to monitor the progress of the Capital Scholars. Students who continued to meet the scholarship eligibility requirements received the same level of scholarship support for their junior and senior years, coupled with financial aid packages to meet each student's needs. Students were required to apply for the Continuing Student Scholarship Program each Spring beginning the last semester they received S-STEM scholarship support. Students with scholarships are required to continue meeting with the College Advisor twice a semester. Students continued meeting with their faculty mentors and taking advantage of career planning services and the annual Career Fair.

Fig 1. A study conducted by the National Center for Education Statistics about 63% of students who started in 2013 and completed in 2019 shows the graduation rate of three types of educational institutions.

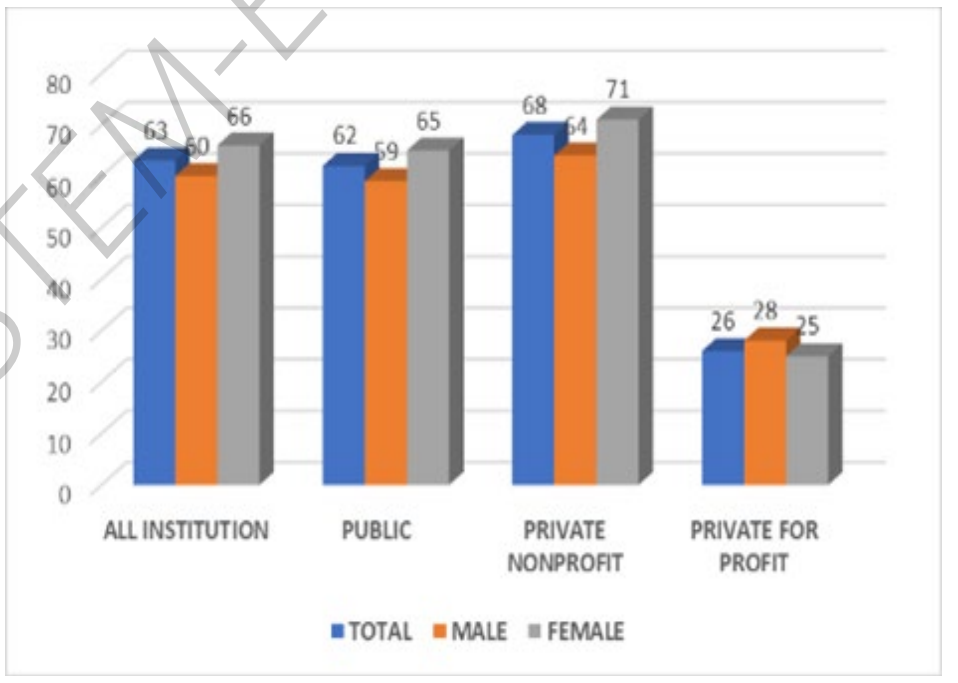

Figure.1 Student started in 2013 and completed in 2019[NCES,2019]

Fig 2A., shows the result of the first NSF S-STEM grant at Capitol Technology University. Cohort 1, Cohort 2, and Cohort 3 show 65%, 46%, and 21% improvement in the graduation rate.

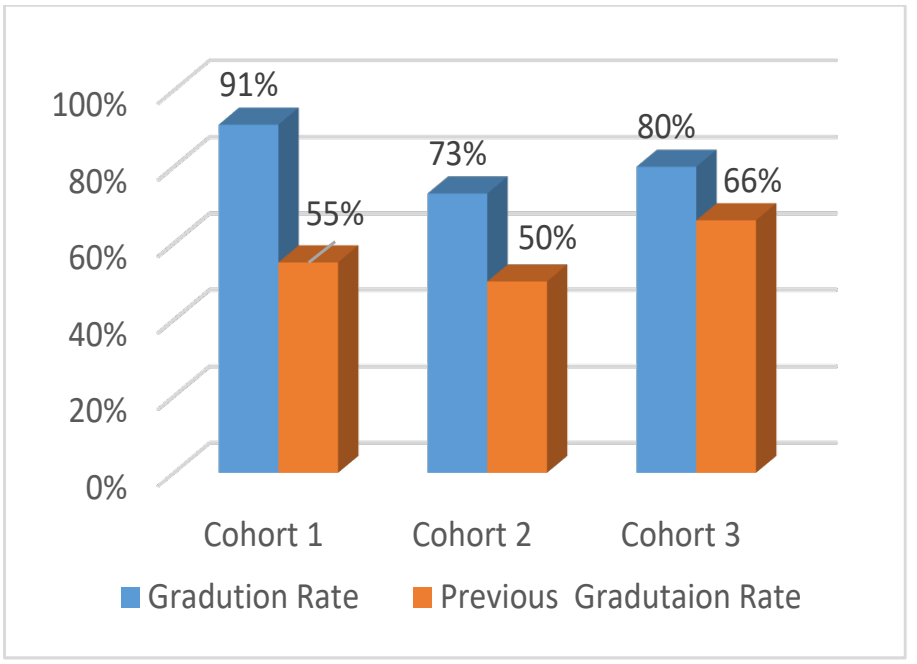

Figure 2A. Results of First S-STEM Grant

Fig 2B., shows the dropout rate for Cohort 1, Cohort 2, and Cohort 3, which are 33.33%, 50%, and 11% respectively.

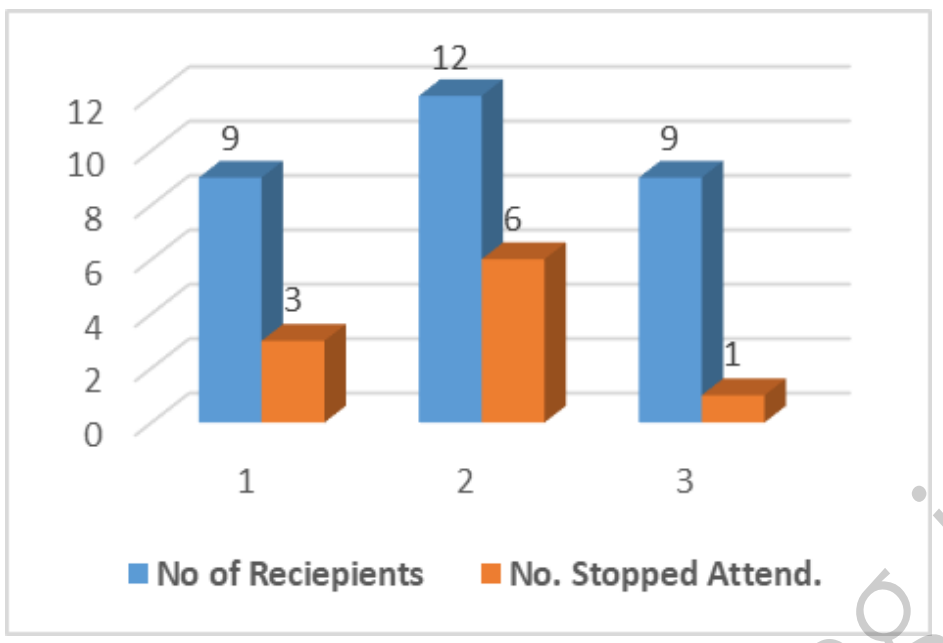

Figure 2B. Results of First S-STEM Grant

Fig 3A., shows the result of the first NSF S-STEM grant at Capitol Technology University. Cohort 1, Cohort 2, and Cohort 3 show 28%, 0% and 43 % improvement in graduation rate.

Figure 3A. Results of Second S-STEM Grant

Fig 2B., shows the dropout rate for Cohort 1, Cohort 2, and Cohort 3, which are 33.33%, 0%, and 25% respectively. One can notice that Cohort 1 has the highest dropout rate and is still much lower than the national 50-year of dropout rate.

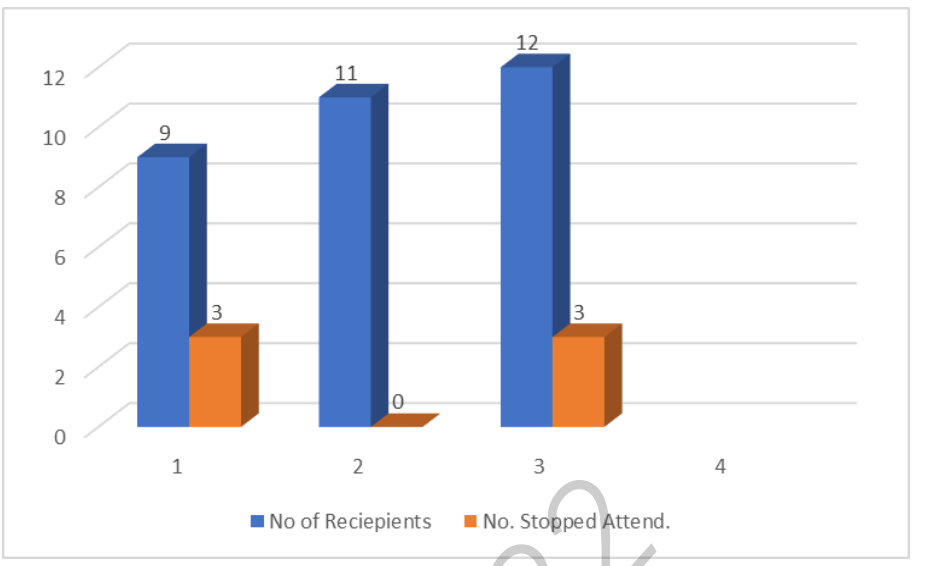

Figure 3B. Results of Second S-STEM Grant

Fig 4A., shows the result of the first NSF S-STEM grant at Capitol Technology University. Cohort 1, Cohort 2, and Cohort 3 show 0%, 0% and 0 % improvement in graduation rate. We did not have data for the Results of the Third S-STEM Grant.

Fig 4B., shows the dropout rate for Cohort 1, Cohort 2, and Cohort 3, which are 40%, 44%, and 27.27% respectively. One can notice that Cohort 1 has the highest dropout rate and is still much lower than the national 50-year of dropout rate.

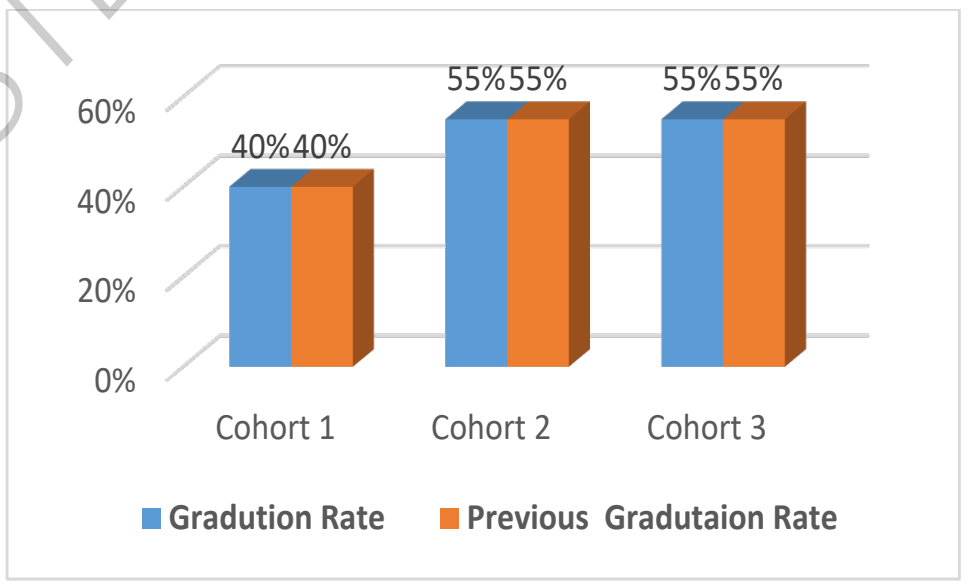

Figure 4A. Results of Third S-STEM Grant

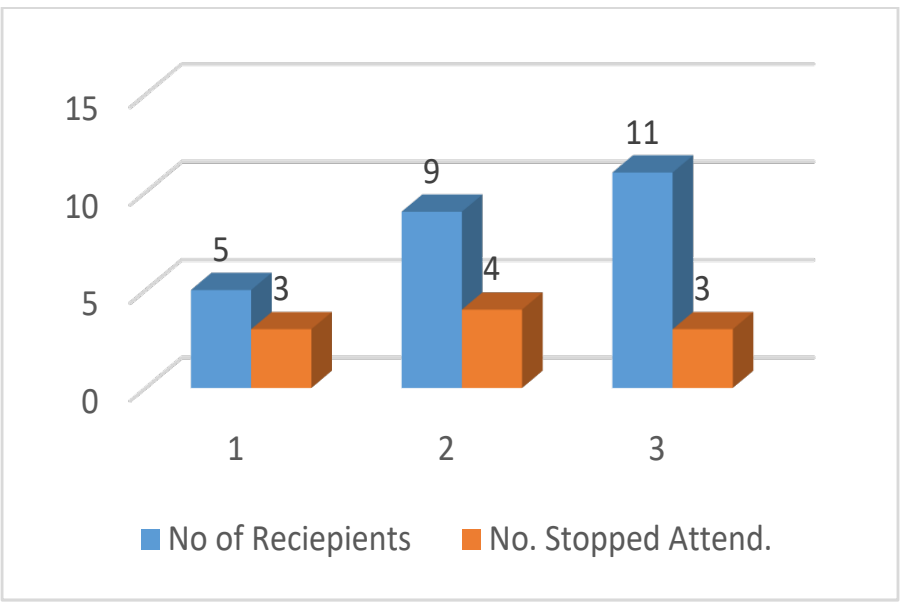

Figure 4B. Results of Third S-STEM Grant

Figure 5A shows 14% of part-time full-time students, and 34 percent of full-time students enrolled.

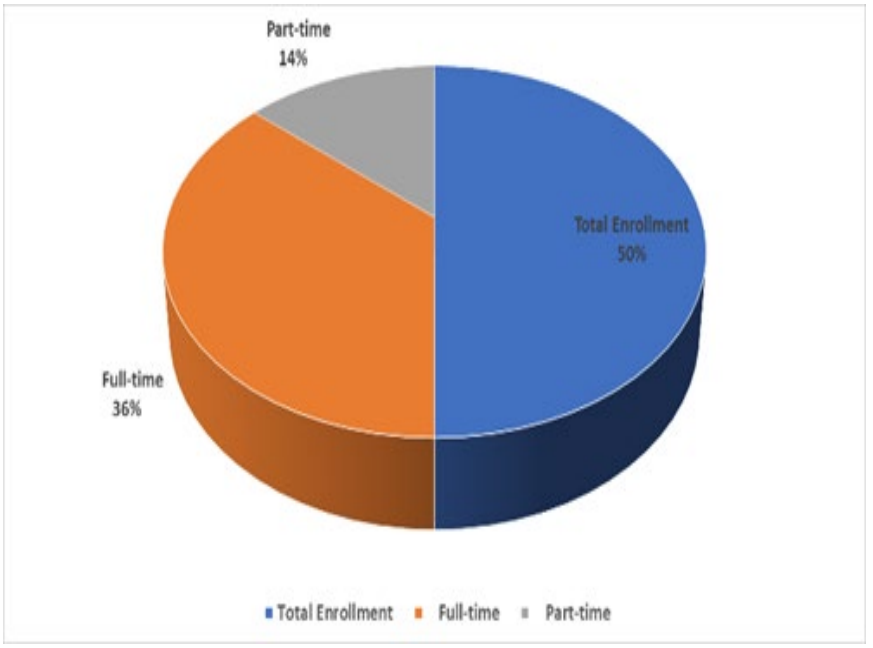

Figure 5A. Enrollment full time and part-time demographics for STEM Majors

Figure 5B, shows roughly 20% CS and 19% EE departments and 61% distributed among, CE, AE, CIS, EET, and CET departments.

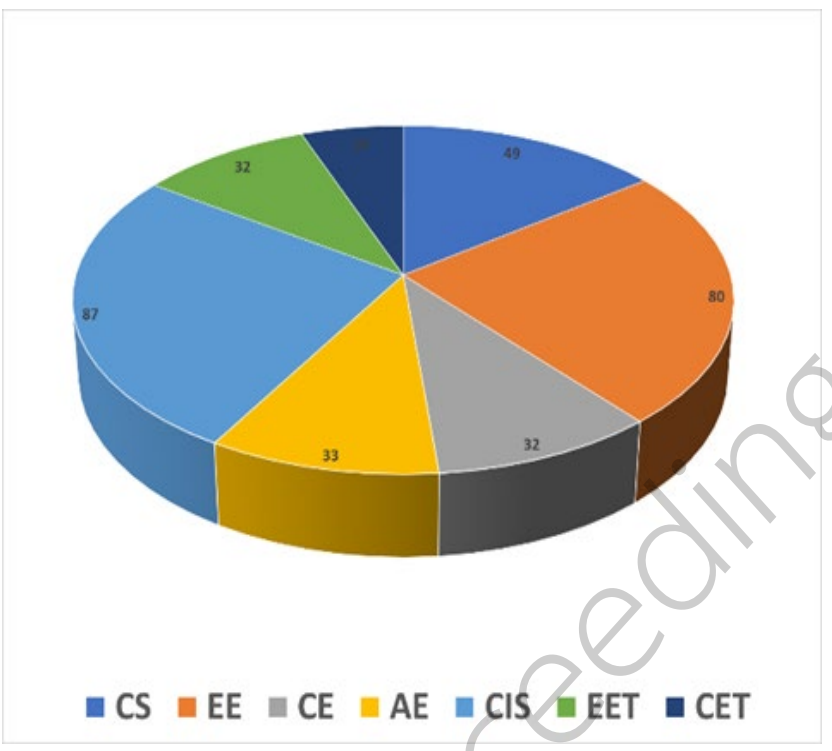

Figure 5B. Enrollment in various department demographics for STEM Majors

The Capital Scholars Program supports the S-STEM program goals by focusing on strategies that promote success during the first two years of college for low-income academically talented students pursuing bachelor's degrees in STEM fields. This is accomplished by studying the effects of career-focused activities on participants' self-efficacy in STEM studies; and by sharing the results of the program and research study results.

Completing the first two years towards a bachelor's degree in a STEM field has been identified as a period of high attrition at Capitol Technology University.

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VII. CONCLUSION

We can notice that the results of the S-STEM bridge program at Capital support the S-STEM program goals by focusing on strategies that promote success during the first two years of college for low-income academically talented students pursuing bachelor's degrees in STEM fields. Our data shows the goal of the summer bridge program is accomplished. Also, Fig 4B. shows the dropout rate for Cohort 1, Cohort 2, and Cohort 3, which are 40%, 44%, and 27.27% respectively. One can notice that Cohort 1 has the highest dropout rate, and it is still much lower than the national 50-year of dropout rate.

Historically, 80 percent of Capitol students who start their third year continue to degree completion. Completing the first two years towards a bachelor's degree in a STEM field has been identified as a period of high attrition at Capitol Technology University.

Overall, there is still a great need for research focused on longitudinal and quantitative assessments of summer bridge programs. Some interesting parameters should include GPAs and low-income, first-generation college students from an ethnic minority background. Also, it should include the use of technology, delivery mode of the summer bridge program, on ground, online, directed, or self-paced. Research is needed to assess whether a subject knowledge or social appetence of students coming from a diverse population.

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Table 4: Enrollment Demographics for STEM Majors

	Capitol	CS	EE	CE	AE	CIS	EET	CET
CURRENT								
Total Enrollment	417	49	80	32	33	87	32	19
Full-time	303	43	49	27	31	71	22	16
Part-time	114	6	31	5	2	16	10	3
Retention, 1 year	75%	60%	0%	100%	75%	100%	75%	57%
Retention, first 2 yrs. (to Jr. status)	60%	85%	60%	71%	37.5%	68%	50%	40%
B.S. (# awarded)	83	2	31	6	7	18	4	0
B.S. Rate (%)	33%	22%	75%	80%	66%	50%	13%	43%
EXPECTED								
Total Enrollment	520	69	104	46	46	108	46	31
Full-time	400	52	76	39	39	80	39	24
Part-Time	120	17	28	7	13	18	7	7
B.S. (# awarded)	97	7	31	6	6	32	5	3

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Predicting Students' Performance in Mixed-mode Learning Strategy using Neural Network Modelling

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Abstract

This paper predicts students' performance using neural network (NN) modelling within the Science, Technology, Engineering, and Mathematics (STEM) subject. he mixed- mode learning (MML) strategy is considered in this study based on Bloom's Taxonomy, flipped classroom, asynchronous and cognitive learning. Standard statistical analyses are included to explore the: i) relationships between the variables; ii) statistically significant predictor variables for the NN and; iii) regression analysis with estimated regression coefficients. The Broyden-Fletcher-Goldfarb-Shanno (BFGS) Quasi-Newton algorithm is applied as the training rule for NN. The prediction results provide an insight of the MML strategy in supporting and improving students' learning experience and their final academic performance. The NN model has also achieved a good level of prediction accuracy.

Keywords— Mixed-mode Learning, Statistical Evaluations, Neural Network, BFGS Quasi-Newton Algorithm

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Predicting Students' Performance in Mixed-mode Learning Strategy using Neural Network Modelling

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***Abstract*—This paper predicts students' performance using neural network (NN) modelling within the Science, Technology, Engineering, and Mathematics (STEM) subject. The mixed-mode learning (MML) strategy is considered in this study based on Bloom's Taxonomy, flipped classroom, asynchronous and cognitive learning. Standard statistical analyses are included to explore the: i) relationships between the variables; ii) statistically significant predictor variables for the NN and; iii) regression analysis with estimated regression coefficients. The Broyden-Fletcher-Goldfarb-Shanno (BFGS) Quasi-Newton algorithm is applied as the training rule for NN. The prediction results provide an insight of the MML strategy in supporting and improving students' learning experience and their final academic performance. The NN model has also achieved a good level of prediction accuracy.**

***Index Terms*—Mixed-mode Learning, Statistical Evaluations, Neural Network, BFGS Quasi-Newton Algorithm**

I. Introduction

The world ministerial meeting highlighted the importance of focusing the COVID-19 education recovery by prioritising the suitable mixed-mode learning (MML) strategies. This paper predicts students' performance in mixed-mode learning strategy using neural network (NN) modelling within the STEM subject. The evaluation is done using the statistical analysis, and the NN as the machine learning. The end of the evaluation provides an insight of the appropriateness of the MML strategy in supporting and improving students' learning experience and their final academic performance. The MML strategy is based on the Bloom's Taxonomy in combination with the flipped classroom, asynchronous and cognitive learning. The summative assessment data is obtained through students' assessment results and from the educational data analytic platform. Conventional statistical evaluations including Analysis of Variance (ANOVA) and multiple regression analysis are computed. The NN modelling is applied that predicts the students' final academic performance based on their learning experiences and early pre-assessments. The BFGS Quasi-Newton Algorithm is applied as the training rule. The performance of the NN model is evaluated through the error performance.

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II. Literature Review

A. Mixed-mode learning model

The MML strategy is adopted from the earlier study [1]. It is based on the Bloom's Taxonomy model in combination of the flipped classroom, asynchronous and cognitive learning. In *Flipped classroom*, the pre-classroom (offline) activities include the pre-live lecture activities/tasks to be completed by students at their own pace within the recommended schedules. The virtual-classroom (online) activities include live lectures and problem-based solving exercises and further Q&A sessions. Finally, the post-classroom activities include the assessment through quizzes, homework, labs, class tests and the final exam. Students are more engaging in online education if some resources are discussed in live-lectures that promote the upper thinking skills of Bloom's taxonomy [2].

The flipped classroom is closely tied to the *Asynchronous Learning*. It endorses students' flexibility of options and controls based on "Anytime, Anywhere" basis. Together, the *Cognitive learning* ties closely with MML that can help students learn effectively by activating the prior cognitive knowledge on knowledge and comprehension within Bloom's taxonomy to enable students to learn actively [3].

B. Educational data mining with machine learning techniques

A semi-supervised machine learning approach was adopted as an early system alert of vulnerable students struggling in their term-time studies [4]. The result, however, demonstrated that the small portion of struggling students may be big enough to qualify at outliers in the machine learning prediction modelling. Therefore, further fine tuning of the thresholds using

XGBoost or Random Forest would be beneficial to determine the anomaly scores [4]. A systematic literature review from 2009 to 2021 about relevant educational data mining (EDM) techniques based on two types of datasets: online learning platform and university databases was performed in predicting students' at-risk and dropout students [5]. Nonetheless, most of the EDM techniques are lack of evaluating the effectiveness of MML strategies in supporting students' learning interactions and their academic performances [5].

In summary, various MML strategies can be quantified for the effectiveness for educational improvement purposes. Therefore, this paper focuses on utilising the NN to predict students' learning experience and academic performance based-on the implemented MML strategy. The NN model is the most fundamental machine learning algorithm and has been extraordinarily well received in EDM [6], [7], where various training algorithms could be applied within the NN depending on the complexity of the model, testing, validation and the training of the dataset.

III. METHODOLOGY

A. Course overview

A total of 181 Year 3 undergraduate students are enrolled to a programming module and is delivered based on the MML strategy. The module is delivered based on the mixture of offline (pre-recorded lectures, quizzes and labs) and online (live lectures and tutorials, mock test) activities. Students accomplish all the tasks through the Moodle learning portal.

An example of Asynchronous Learning schedule utilising the anytime, anywhere is shown in Table I. Four demonstrators as the Teachers of records are available for the pre-recorded video session in class (Offline session), and it is up to the students to attend the pre-recorded video sessions or, watch in their own time (in off-campus). Pre-recorded videos are made with shorter lengths, more coding examples, demonstrations and less challenging compared with live lectures. Microsoft Teams, Zooms and Moodle are used as the core lecturing, learning and the course management platform to enable students to access all the required resources.

TABLE I. TIMETABLE SCHEDULE

Session	Week 1	Week 2	Week 3	Week 4
Thursday, 08:00 - 08:30 am	Intro-Live	Offline	Live	Tutorial
Thursday, 08:30 - 09:00 am	Live	Offline	Offline	Tutorial
Thursday, 09:10 - 09:30 am	Live	Live	Offline	Office Hour + Revision
Thursday, 09:30 - 10:00 am	Live	Live	Live	Office Hour + Revision

B. Dataset information

Summative assessments from the labs, class test and final exam across 181 Year 3 undergraduate students are collected for the statistical analysis, NN modelling prediction and verification. The EDM is obtained through the Echo360's Smart video capture and data analytic platform [8]. The platform assembles the course data analytics for enrolled students. As not all the dataset information are relevant to the NN modelling, only the relevant data metrics such as the *Total engagement* and *Attendance* are extracted from the Echo360 platform. The *Total Engagement* metric accumulates total of data points such as Video Views, Q&A Entries, Polling Responses and Confusion Alerts. The *Attendance* metric records the students' attendance of the virtual online classroom during the class time and also the offline classroom activities where students' watch the pre-recorded videos. All data metrics obtained in this study follow strictly the General Data Protection Regulation (GDPR)'s policy [9].

C. Statistical analysis

Multiple regression analysis is performed that checks whether the dependent (target or output) variable could be predicted using the considered independent (input) variables. It also informs the total variability in the dataset. ANOVA checks whether independent variables affect the dependent variable in a regression model. In order to measure the degree of linear correlation between the input independent variables a_i (four lab assessments, metrics from Echo360 and the class test score) and the output dependent variable b (final exam score), the Pearson correlation coefficients $r(a_i, b)$ are applied. The correlated independent variables denote the suitability of the input variables as inputs for the later NN modelling.

D. Neural network modelling and verification

The NN predicts the students' academic performance as the target output through the input information of students' engagement metrics from Echo360's data analytic platform and their assessments results. The earlier research works about NN modelling are cited here and followed [10]. The performance of the NN model will not be compared with other machine learning techniques.

In general, the educational data gained from Echo360 and the assessments are inputs (x_i) of the NN model. Input variables are assigned by weights (w) and are summed. The input layer in NN is fed to the hidden layer. The hidden layer performs the main computation. Finally, the weighted sum of input elements x_i and w_{ij} provides the output neuron Y_j. w_{ij} in this case is updated recursively.

$$Y_{j,predicted} = b + f\left(\sum_{i=1}^{N_i} w_{ij} x_i\right). \tag{1}$$

The i refers to the current ith connection line to jth neuron. x_i is the output value from the previous ith neuron. N_i is the total number of connection lines. The b is the bias. It serves as the input to all nodes through the multiplication of w_{ij} and x_i to b. The b in this case is set to 1 for simplicity purposes. Overall, the $f(z)$ is the activation function where z is the aggregation of the inputs x_i.

The w_{ij} is fine-tuned (trained) through the back-propagation (BP) that aims to reduce the computation errors and in turn improve the NN accuracy of the desired output. The error is computed as the sum of square difference between the target value t_j and the desired output y_j:

$$E = \frac{1}{2}\sum_{j}^{N_j} (y_j - t_j)^2. \tag{2}$$

To effectively train the NN model, the Broyden-Fletcher-Goldfarb-Shanno (BFGS) Quasi-Newton BP algorithm is used as an alternative to the conjugate gradient methods without any constraints. The computation technique is followed that resembles the NN nonlinear optimiser [11]:

$$x_{k+1} = x_k - H_i^{-1} grad\,(x_k)\,, \tag{3}$$

where H_i^{-1} is the Hessian matrix to the current value of weights w_{ij} and bias b. The k indexes the iteration of the previous x_k and the updated x_{k+1} using the inputs x_i.

The update of x_{k+1} is computed as a function of the gradient according to the following:

$$\tilde{\mathbf{X}} = \tilde{\mathbf{X}} + h * d\tilde{\mathbf{X}}, \tag{4}$$

where $\mathrm{d}\vec{X}$ is the search direction. The h is selected to minimise the performance along with $\mathrm{d}\vec{X}$ so that the optimum can eb found. The first $\mathrm{d}\vec{X}$ is set as the negative of the gradient of performance. For the next and consecutive iterations the search direction is computed as:

$$d\tilde{\mathbf{X}} = \frac{-H}{g\tilde{\mathbf{X}}}, \tag{5}$$

where $\mathrm{g}\tilde{\mathbf{X}}$ is the gradient and H is the Hessian matrix. The training stops when any of the conditions met:

- The maximum number of epochs (repetitions) reaches.
- The maximum amount of simulation time exceeds.
- The validation performance has increased consecutively.

The Mean Square Error (MSE) is used to evaluate the performance of NN:

$$MSE = \frac{1}{N_i N_j} \sum_{j=1}^{N_j} \sum_{i=1}^{N_i} (y_{ij} - t_{ij})^2 . \tag{6}$$

IV. Statistical analysis

The multiple regression analysis validates the dependent variable (Final Exam) and independent variables – Lab and class test scores, *Total Engagement* and the *Attendance* metrics from the Echo360 platform. Outcomes of the statistical analysis are evaluated as the multiple regression analysis summary, ANOVA and significance analysis of independent variables.

In Table II, the R value of 0.84 affirms the suitability of the independent variables as the good predictors for the dependent variable. Additionally, the adjusted R^2 value of 0.55 implies the 55% variability of the independent variables to the final dependent variable (the final exam score).

The initial ANOVA checks the goodness of fits for the multiple regression. As $\alpha < 0.05$, this shows variables considered are a good fit and predictor for the NN model.

The final statistical testing checks the significance for each of the independent variables in relation to the dependent variable. Table III shows the significance of each independent variables of labs, *Total Engagement*, *Attendance* metrics and class test in relation to the final exam as the dependent variable. As $\alpha < 0.05$, this further validates the applicability of all independent variables used for the NN modelling to predict the dependent variable.

TABLE II. Summary of the Multiple Regression Analysis

Multiple R	0.84
R^2	0.55
Adjusted R^2	0.55
Standard Error	5.4

TABLE III. Statistical significance of the independent variables.

Model	Coefficients	Standard error	t Stat	α
(Intercept)	92	25	15	0.02
Lab 1	-0.35	0.08	-3.5	0.01
Lab 2	-0.25	0.04	-3.9	0.01
Lab 3	-0.45	0.05	12.13	0.01
Lab 4	-0.14	0.07	-2.80	0.02
Total Engagement	-0.13	0.25	-3.5	0.01
Attendance	15.32	1.45	7.25	0.002
Class Test	5.4	1.5	4.8	0.002

Pearson correlation coefficients values of the total engagement, attendance, lab scores, class test score towards the final exam score are shown in Table IV. The relationship with ascending order are: Lab 2, Lab 1, Lab 3, Lab 4, Total Engagement, Attendance and the Class Test. Unsurprisingly, it can be seen that the most of the correlation coefficient values increase from the labs, class test and the final exam. Apart from that, the *Attendance* metric and the final exam correlation value is with the highest.

V. Results

A. NN setups

The MathWorks MATLAB is used for the NN modelling. The input layer consists of seven independent variables (four lab assessment scores, the *Engagement* and *Attendance* metrics and the class test score). For the best simulation settings, the NN model contains two hidden layers with 20 neurons in each of the hidden layer. The hidden layers are fed into a final single output neuron that predicts the dependent variable (final exam score). The hyperbolic tangent is used as the activation function. Data samples of 181 students are mixed into the training, validation and test ratio of 0.7, 0.15 and 0.15. For the training and learning phase, the BFGS Quasi-Newton BP algorithm is applied. The training epoch is set to 1,000.

B. NN simulation results

The NN model training regression plot at Epoch = 20 is shown in Fig. 1. In this case, the regression plots achieve marginal good fits with the R-value of 0.72. This proves a good data fitting of the predicted outputs y_{ij} that converge closely with the target outputs t_{ij}. In other words, the MML strategy in this case can be explained in the NN model to successfully predict students' final academic performance.

For the NN validation, the MSE of $\approx$ 58.2 or 5.5% (<10%) signifies the good performance of NN in training and validation settings. The decreasing error distributions from the

TABLE IV. CORRELATION COEFFICIENT OF FOUR LAB SCORES, TOTAL ENGAGEMENT AND ATTENDANCE, THE CLASS TEST AND THE FINAL EXAM SCORE.

	Lab 1	**Lab 2**	**Lab 3**	**Lab 4**	**Total Engagement**	**Attendance**	**Class Test**	**Final Exam**
Lab 1	1							
Lab 2	0.75	1						
Lab 3	0.70	0.65	1					
Lab 4	0.80	0.85	0.86	1				
Total Engagement	0.34	0.35	0.25	0.40	1			
Attendance	0.24	0.25	0.32	0.35	0.54	1		
Class Test	0.34	0.31	0.42	0.45	0.45	0.48	1	
Final Exam	0.45	0.35	0.52	0.54	0.66	0.68	0.72	1

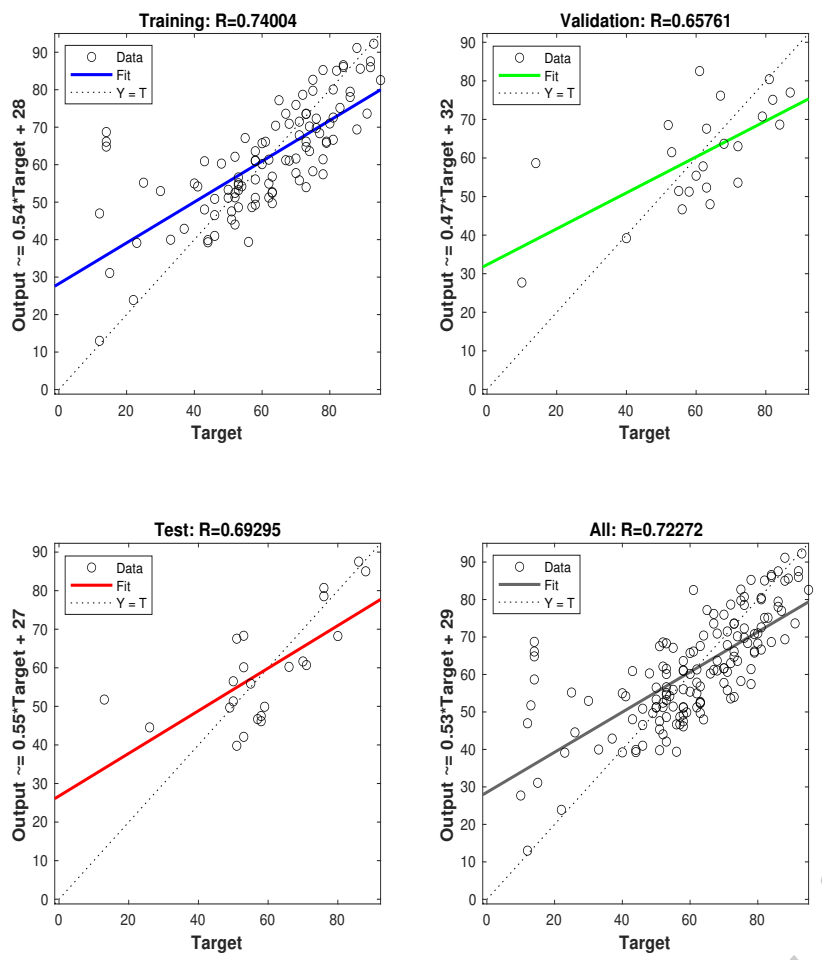

Fig. 1. Regression plot for NN: Top left: Training data; Bottom left: Test data; Top right: validation data; Bottom right; overall regressions.

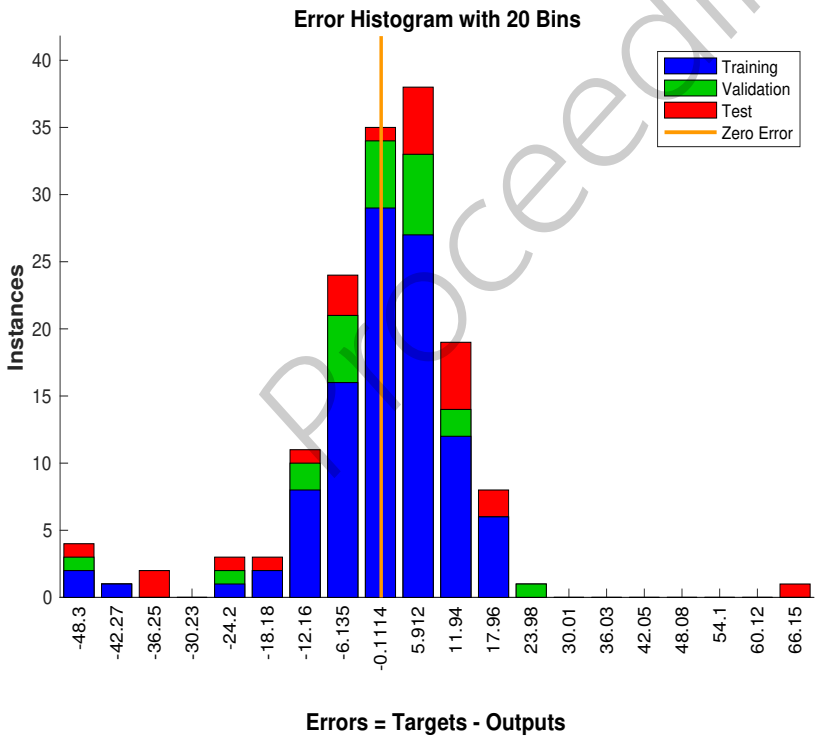

Fig. 2. Error histogram distribution plot.

zeroth point of the error histogram plot in Fig. 2 validates the successfulness prediction of the NN with acceptable error distributions and relatively low MSE values.

VI. CONCLUSIONS

This paper demonstrated the students' performance that has been predicted successfully using NN modelling with good level accuracy. Through the multiple regression analysis and ANOVA, the statistically significance of the results proof the applicability of the independent variables as the predictor for the dependent variable for the NN model. Additionally, the correlation analysis showed the positive relationships of all the independent variables towards the dependent variable.

Even though the NN modelling has been successful, there are still notable limitation in this this study where the classification is not accomplished due to insufficient amount of datasets. The immediate work should focus on feature extraction and transformation on the dataset. The future advancement of EDM with machine learning could shape a better educational framework with 'smart' decision making capability that quantifies students' performance learning pathways based on their learning experiences and behaviours.

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Demonstration-based Teaching through the Simurelay Program to Develop Hands-on Practical Skills in Electric Motor Control Course

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Abstract

Demonstration-based Teaching through the Simurelay Program to Develop Hands-on Practical Skills in Electric Motor Control Course. The purpose for 1) Develop a worksheet on motor control 2) To assess the quality of the demonstration learning management through the Simurelay program to develop practical skills on motor control 3) To assess the operability of the manual motor control. The statistics for the quality analysis of the tools are: Accuracy and the statistics for data analysis are mean, standard deviation, and percentage. The results showed that 1) Development of a worksheet on motor control with a score of accuracy or reliability (IOC) of the motor control sheet that passed the criteria, the average IOC will be 0.67-1.00 2) Demonstration learning management through the program to develop the motor control wiring skills. 3) The overall

quality of the activities was at a good level (mean = 4.48, S.D. = 0.91). Considering each aspect, it was found that the level was very good. The aspect with the highest mean was "The learning media" (mean = 4.78, S.D. = 0.383) 4) The students had skills in operating circuits to control electric motors by hands on skills, which passed the criteria, accounting for 84.69% have qualified 100%.

Keywords—Demonstration learning, Practical skill, Manual motor control circuit

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Demonstration-based Teaching through the Simurelay Program to Develop Hands-on Practical Skills in Electric Motor Control Course

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***Abstract*— Demonstration-based Teaching through the Simurelay Program to Develop Hands-on Practical Skills in Electric Motor Control Course. The purpose for 1) Develop a worksheet on motor control 2) To assess the quality of the demonstration learning management through the Simurelay program to develop practical skills on motor control 3) To assess the operability of the manual motor control. The statistics for the quality analysis of the tools are: Accuracy and the statistics for data analysis are mean, standard deviation, and percentage. The results showed that 1) Development of a worksheet on motor control with a score of accuracy or reliability (IOC) of the motor control sheet that passed the criteria, the average IOC will be 0.67-1.00 2) Demonstration learning management through the program to develop the motor control wiring skills. 3) The overall quality of the activities was at a good level (mean = 4.48, S.D. = 0.91). Considering each aspect, it was found that the level was very good. The aspect with the highest mean was "The learning media (mean = 4.78, S.D. = 0.383) 4) The students had skills in operating circuits to control electric motors by hands on skills, which passed the criteria, accounting for 84.69%. have qualified 100%**

Keywords—*Demonstration learning, Practical skill, Manual motor control circuit*

I. INTRODUCTION

The direction of the country's development in the National Strategy (2018-2037) has set important development goals to develop people in all dimensions and at all ages to be good, competent, and qualified people. Thai people are ready in physically, mentally, and intellectually with good development all around also have responsibility to society and others, have discipline, maintain morality and be a good citizen of the nation, have the right principles and gain the skills needed in the 21st century, such as the ability to act, the ability to solve problems, adapt, communicate, and work with others more effectively, have a habit of continually learning throughout life. The National Strategy (2018), the National Education Plan (2017-2036), has set out on human resource development as a crucial mechanism for bringing the country into a global society in the 21st century and the key issue has been set out in the National Strategy and Thailand 4.0 strategy. The preparation of manpower in terms of knowledge and skills essential competencies such as analytical thinking Ability to solve problems, communicate and work as a team, etc., in order to stay up to date with the changing trends of the dynamic world. The National Education Plan (2017) Characteristics or indicators of learners' ability to practice self-confidence [6] Prapatsara Kotakun (2012) the learners gain knowledge and understanding from direct experience, making it clear from the learning experience, bring coping skills, solve problems skills and make decisions to be useful in their application in life. [4] Thissana Khaemanee (2007) practical ability is an important skill that should be developed for learners along with learning outcomes in various subjects.

The skilled work in which learners lack practical ability will lead to occupational hazards (Amnat Chonpitak, interviewee, June 14, 2021). Teaching in practical subjects is an instruction that develops learners to have potential in thinking, problem solving, and applying knowledge in theoretical learning. The practing course is a course that allows learners and teachers to participate and interact in learning, discussing, and exchanging ideas, and also trains students to work in groups and to share duties if the learners are absent. The ability to practice students will lack discipline in work. When problems at work may not be resolved as well as they should, social skills will also decline (Prapisri Laorsi, interviewee, 17 June 2021). And the science in the technician will focus a lot on practice. The ability to practice will allow students to apply the knowledge of theory subjects to real practice. Including real work situations and awareness of safety at work, this skill is considered a very necessary skill in this field of technicians, which if the learner lacks the ability to practice, it will not be able to do it. Learned or may practice without expertise/prudence will create a risk for both learners and users. It also prevents students from solving specific problems that may arise on the job site (Virapong Udomphon, interviewee, 17 June

2021). It also corresponds to the issue of learning development, reform of learning processes that respond to changes in the 21st century by developing learning processes at all levels, from early childhood to higher education that use knowledge-based and interdisciplinary thinking systems for development process learning of learners at all levels of education, including activities to enhance skills and develop an integrated learning system that emphasizes action. The National Strategy Board (2019) can therefore conclude that practical ability is a skill that learners should learn. And it is also a problem that should be improved.

From the importance of the ability to operate the electric motor control circuit by hand. The course of electric motor control and problem solving by teaching the above demonstration. Therefore, the researcher is interested in researching the development of motor control circuits by using a demonstration learning management through Simurelay program to develop practical skills on manual motor control circuits in the subject of electric motor control. The target group is undergraduate students. It is expected that after learning is managed, students will have the learning behaviors as intended and apply it to life in the future

II. OBJECTIVES

1. To assess the quality of the demonstration learning management through the Simurelay program to develop practical skills on the manual motor control circuit in electric motor control

2. To compare the operate ability the electric motor control circuit by hand in the subject of electric motor control with criteria 70%.

III. RESEARCH HYPOTHESIS

1. The accuracy or reliability of the motor control experimental worksheet to develop practical skills on electric motor control circuits passed the criteria (score 0.50 or higher).

2. Demonstration learning management to develop practical skills on electric motor control circuits by electric motor control course by applying the concept of demonstration learning management based on the concept of [5] Thisana Khaemenee (2008), with the following steps: 1) creating interest in learners 2) educating learners 3) training readiness in practice 4) practice ability to practice 5) lesson summary and 6) measure practical ability

3.After learning with demonstration learning activities through Simurelay program to develop skills in working on motor control circuits by hand, not less than 70% have skills in operating electric motor control circuits by hand that pass the criteria (Score 50% or more)

IV. RESEARCH METHOD

In the research the Demonstration learning through the Simurelay Program to develop Practical Skills in Motor Control Circuit by Hand in Electric Motor Control Course is an experimental type of research. By using the preliminary experimental research model, the one-group experiment, measuring the results only after the experiment (The One-Shot Case Study Design, posttest-design) according to the concept of [6] Pariwat Khueankaew (2008) with the following steps:

4.1 Populations and samples

The populations and samples are 20 students from the 2nd year bachelor's degree students, Bachelor of Technology program electrical technology major: Faculty of Industrial Education Technology, King Mongkut's University of Technology Thonburi in 2/2021 academic year by specific random sampling

4.2 Research instruments

Methods for creating and qualifying tools with a specific purpose/topic of the experimental worksheet and consists of a total of 5 worksheets, studying theories, concepts, documents and research papers in order to understand the principles of creating experimental worksheets to created a motor control experiment worksheet. From the desired indicator according to the objective which from the principle of choosing to develop learner indicators and present the experimental worksheets created to the experts. The Content Conformity Assessment (IOC) for experts to determine the validity of the content or to consider the consistency between the question and the object (Item-Objective Congruence: IOC).

4.2.1 Motor control worksheet for developing practical skills in electric motor control circuits by hand

4.2.2 Quality assessment form of demonstration learning activities for developing practical skills on manual motor control circuits' 5-sided electric motor control

4.2.3 A practical ability measure by using the Motor Control Experiment Worksheet to develop the practical skills in the manual motor control electric circuit by using the Manual Motor Starting Experiment Worksheet. All 5 worksheets have 3 side indicators**.**

4.3 Data Collection Methods

Demonstration learning management for developing practical skills in electric motor control circuits in the subject of electric motor control. The researcher conducted the experiment with a random sample of 20 people using the research model. The One-Shot Case Study Design, posttest-design based

on the concept of [6] Pariwat Khueankaew (2008) is as follows:

Experimental chart E-Group

Fig 1. Show the experimental scheme.

In the experimental flowchart, various symbols were used to convey the following meanings.

E-Group = an experimental group of 20 people

X = experimental variable: Demonstration learning management

O = dependent variable: the motor control electric circuit operation skills

V. DATA ANALYSIS

5.1 Quality analysis of research tools

Analyze the validity or accuracy by calculating the correspondence between the question and the object (Item Objective Congruence (IOC)). A validity assessment form for all 5 experimental worksheets from content experts by having quality assessment experts calculate IOC values.

5.2 Objective Data Analysis and experimenting with hypotheses

5.2.1 Analyze the quality of the demonstration learning management activities to develop practical skills on manual motor control circuits in order to examine the stated research hypotheses “The quality of the activities is better level” and analyze the quality of activities obtained from the assessment of experts by calculating the mean and the standard deviation then compare the mean with the mean range to indicate the quality level, the acceptable values are level up The average range of 3.50 - 4.49 is of good quality.

5.2.2 Analyze the scores of the experimental worksheet to develop practical skills in electric motor control circuits in the subject of electric motor control to verify the research hypothesis that said “After learning with demonstration learning activities through Simurelay program, to develop practical skills on manual motor control circuits in the subject of electric motor control are not less than 70 percent with a better skill in operating electric motor control circuits by hand”, which is a group score with a passing criterion more than 50 percent.

5.3 Statistics used in data analysis

The accuracy by using the formula for finding the consistency IOC (Index of Item Objective Congruence), Mean, Standard Deviation: SD, Percentage

VI. SUMMARY OF RESEARCH RESULTS

6.1 The development of motor control worksheets to develop practical skills in electric motor control circuits by hand The generated worksheets have a validity score (IOC) of all 5 qualifying motor control worksheets, with an average IOC of 0.67-1.00, which is considered consistent with the established hypothesis.

6.2 Demonstration learning through Simurelay program to develop practical skills on manual motor control circuits in electric motor control course. The sequence of steps in the training is as follows: Step 1 Creating Interest Step 2 Educating students in each of the 5 worksheets of the experiment, divided into 1 worksheet per week. Step 3 Practice readiness for practice. Instructors will distribute worksheets for each experiment for learners to study the working principles of different motor connections. Step 4. Practice your ability to practice. The teacher divides the learners into groups of 2-3 people, a total of 7 groups, then let the learners do the experimental worksheets and the instructor demonstrates through the Simurelay program and allows the learners to compare the results of the hands-on exercises. Step 5 Lesson Summary The teacher summarizes the content by summarizing each worksheet separately and having the learners explain the working principle. Step 6 Measure the practical ability for learners to complete the circuit from the 5 experimental worksheets.

6.3 The overall quality of learning management activities was at a good level (mean = 4.48, S.D. = 0.91). When considering each aspect, it was found that the level was very good in all aspects. The top 3 aspects with the highest average from highest to lowest were “Learning Media (mean = 4.78, S.D. = 0.38), followed by the learning activities aspect (mean = 4.73, S.D. = 0.46) and the overall structure of the plan (mean = 4.53, S.D. = 0.81) were considered consistent with the stated assumptions.

6.4 Results of a study on the ability to operate the electric motor control circuit by hand show the percentage of operating capability for manual motor control circuits for 7 groups as shown in Table 1.

TABLE I SHOW THE PERCENTAGE OF THE ABILITY OF OPERATING CAPABILITY IN MOTOR CONTROL CIRCUITS BY HAND.

Group	Target score (155)	Result		Percentage
		Pass	Fail	
1	123	√		79.35
2	133	√		85.80
3	123	√		79.35
4	126	√		81.29
5	129	√		83.22
6	140	√		90.32
7	140	√		90.32
Total group pass		7		84.23

Students have practical skills in electric motor control circuits by hand, passing the criteria, accounting for 84.23%

and have qualified 100 percent is considered consistent with the assumptions set is "after learning with the Simurelay Demonstration Program Learning Management Activity to develop for developing practical skills on electric motor control circuits by subject electric motor control not less than 70 percent

Fig 2. Three phase motor control circuit operating set

Fig 3. Doing activities according to the experimental worksheet

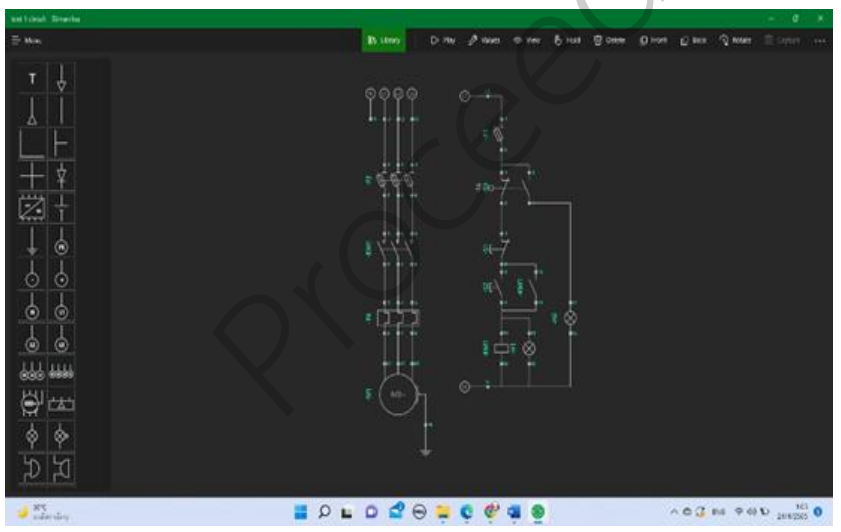

Fig 4. Demonstration learning management through Simurelay

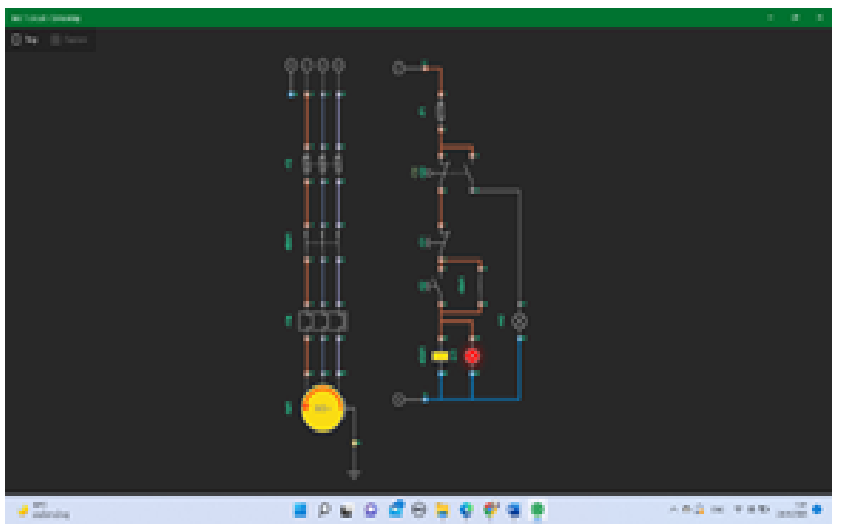

Fig 5. Program to develop hands-on motor control circuitry skills in motor control subject

VII. SUGGESTION

Therefore, there are suggestions for improving research development as follows.

1. Before practice, teacher should teach the theory of how the devices works because even though there is such information in the experiment sheet some students did not read and understand the information given in the worksheet.

2. An experimental set to use to develop that learner. There should be enough students. So that students can experiment and learn thoroughly and conduct experiments at the same time.

3. The researcher needs to take care of the orderliness of the learners while using the experimental kit to prevent danger during operation and provide advice to learners so that learners can understand the content more.

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P02333

The Development of Simulation Based Interactive e-Learning Course to Enhance Analytical Thinking Skill for Training Student Teacher

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Abstract

The purposes of this research were to : 1) develop interactive e-Learning courses integrated with simulations had the efficiency of 80/80 criteria, 2) compare analytical thinking skill scores before and after learning by using interactive e-Learning courses, and 3) study the students' opinions who studied via the interactive e- Learning courses integrated with simulations. The sample groups of the research were 26 second-year students of bachelor's degree in Teacher Training in Electrical Engineering Department, King Mongkut's University of Technology North Bangkok. Research instruments include interactive e-Learning courses integrated with simulations, assessment form of analytical thinking skill, and evaluation form of students' opinions. The research results shown that 1) the efficiency of interactive e-Learning courses using simulations had the efficient of 82.22/83.74 higher than the 80/80 criteria., 2) the analytical thinking skill scores after learning by using interactive

e-Learning courses were statistically significant higher than before learning at 0.01 level 3) the students' opinions toward learning by using interactive e-Learning courses were at a high level (the mean equaled to 4.26 and S.D. equaled to 0.69).

Keywords— Simulation based Interactive e-Learning courses, Analytical Thinking Skill, Student Teacher

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The Development of Simulation Based Interactive e-Learning Course to Enhance Analytical Thinking Skill for Training Student Teacher

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***Abstract*—** The purposes of this research were to : 1) develop interactive e-Learning courses integrated with simulations had the efficiency of 80/80 criteria, 2) compare analytical thinking skill scores before and after learning by using interactive e-Learning courses, and 3) study the students' opinions who studied via the interactive e-Learning courses integrated with simulations. The sample groups of the research were 26 second-year students of bachelor's degree in Teacher Training in Electrical Engineering Department, King Mongkut's University of Technology North Bangkok. Research instruments include interactive e-Learning courses integrated with simulations, assessment form of analytical thinking skill, and evaluation form of students' opinions. The research results shown that 1) the efficiency of interactive e-Learning courses using simulations had the efficient of 82.22/83.74 higher than the 80/80 criteria., 2) the analytical thinking skill scores after learning by using interactive e-Learning courses were statistically significant higher than before learning at 0.01 level 3) the students' opinions toward learning by using interactive e-Learning courses were at a high level (the mean equaled to 4.26 and S.D. equaled to 0.69).

Keywords*—Simulation based Interactive e-Learning courses, Analytical Thinking Skill, Student Teacher*

I. INTRODUCTION

In 2021, the results of the PISA assessment showed that the analytical thinking abilities of Thai students were lower than international learning standards. It can be seen that Thai education is ranked 55th out of 72 countries around the world which decreased when considering from the past 3 years, while ASEAN countries have a better ranking. PISA's learning assessment was an evaluation of students' knowledge and skills at 3 levels [1], namely Primary 6, Mathayom 4, and Vocational Certificate grad 1 from a representative group of 6,235 students, it was found that the knowledge and skills of Thai students were at the low level. In considering the factors affecting critical thinking skills of Thai students, it can be seen that higher education students have reduced critical thinking abilities reflecting the quality of teaching at different education levels. The key point shows that most students lack critical thinking skills, as a result, learners have limited learning abilities such as memorization, imitation of samples, traditional solution measurement of learning outcomes that are inconsistent with actual learning conditions, etc. Therefore, learner's weaknesses that need to be addressed urgently include interpreting the meaning of the problem, systematic analysis problem solving, and assessment of learning outcomes.

In addition, the current learning and teaching system has changed the learning model to be modern both the normal teaching system and teaching outside the classroom. Learning tools and resources are designed and developed under continuous changes in technology and information systems, such as online media teaching, e-learning [2], simulation based teaching [3] and others. Being modern and integrated teaching model able to cope with technological changes in the 21st century is essential and necessary to help students develop more critical and analytical thinking skills [4].

Department of Teacher training in Electrical Engineering, Faculty of Technical Education, at King Mongkut's University of Technology North Bangkok, is responsible for producing industrial technician teachers for vocational education institutions in Thailand. Teaching methods use the MIAP learning process to create a learning experience for learners. The MIAP learning process [5] consists of 4 steps: 1) Motivation, which is the initial stage by creating interesting problems for each lesson, 2) Information that provides a platform to present interesting content for learners to learn according to their needs, and 3) Application, this is the step where learners practice their skills and do exercises. 4) Progress that is the measurement and evaluation step of learning achievement after the learning process is over. Student teacher will practice teaching skills through the course of teacher training in Electrical Engineering and Education, Faculty of Industrial Education at King Mongkut's University of Technology North Bangkok. The curriculum emphasizes teaching and learning to create experiences in teaching and supervising teaching. The teaching method is grouping of teachers and students into small groups of 7 per teacher. In teaching of the last decade, it was found that learners lacked skills

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and tasks required by professional standards, such as lesson plan design, creating innovative media use of modern learning technology, effective measurement and evaluation techniques, etc. These problems caused by the lack of analytical thinking skills of student teachers. Therefore, researchers will have the concept of developing e-Learning course together with using simulation models to promote diverse analytical thinking processes and the interaction of modern teaching resources. The developed lessons can stimulate the critical thinking process for student teacher who can apply it in the learning and teaching process to effectively and enhance the learning skills in 21st century that are benefit and necessary for a qualified vocational teacher career.

A. Purposes of the research

1. To develop simulation based interactive e-Learning course to promote analytical thinking skills of technical student teacher.

2. To compare the students' achievement through the pre-learning and post-learning analytical thinking scores using interactive e-learning developed using simulations to promote analytical thinking skills.

3. To assess learners' opinions on simulation based interactive e-Learning to promote analytical thinking skills.

B. Research hypothesis

1. Interactive e-Learning course that use simulation to enhance the analytical skills of technical student teacher is efficient according to 80/80 standard criteria.

2. Learning achievement who completed interactive e-Learning course using simulations of post-learning is higher than pre-learning with educational statistic significantly at .01.

3. Students who took interactive e-Learning course using simulations had a high level of satisfaction.

II. LEARNING AND TEACHING MODEL

A. e - Learning

E-Learning is a teaching model that transfers knowledge through information technology such as computer programs, computer system and the internet network. E-Learning is a consistent learning system in computer-aided teaching (CAI) [6] or web-based teaching. In addition, e-Learning is a learning model through information technology for learning and teaching or training, which presents course content in text, images, using animation, video and audio, using web technology to deliver course content.

B. Analytical Thinking Skill

Bloom et al has identified 3 characteristics of analytical thinking [7] as follows: 1) Significance analysis that distinguishes what is important and necessary, or rational role; 2) Relationship and significance analysis that is the story or events that have links, conflicts, and consistency, 3) Principle analysis which is a search for the structure of objects, tools, stories and actions that are linked to related principles and theories.

C. Learning Simulation

A learning simulation was created for learners to learn from the problem condition and promote analytical thinking [3] and reasoning skills in solving problems in daily life. The students developed working in groups to create a learning atmosphere in the classroom in promoting learners are more involved in teaching and learning. It also gives students a broader vision to be able to recognize, understand, and use cause and effect in solving various problems very well.

III. DESIGN AND IMPLEMENTATION

The research was an experimental research with the one group of pretest and posttest design to validate the efficiency of the e-Learning by measuring pre-test and post-test score. The research methods are as follows.

A. Defining a sample group

The sample group was undergraduate students of Department of Teaching Training in Electrical Engineering, Faculty of Technical Education of King Mongkut's University of Technology North Bangkok. A total of 26 students enrolled in Teaching Practice course were selected using a method of purposive sampling.

B. Design of inductive e-Learning

The e-Learning course was designed for the training student teachers. It consists of 4 parts: 1) Learning management section, 2) Communication section using Google Classroom, 3) Lesson content of 10 units: Introductory learning theory, Motivation of lesson, Ohm's law, Series resistor circuit, Diode, Inductive electric potential, Resistor, Current density, Conducting resistance, and Capacitor. The research process has the following steps:

- Analyze and construct course content in consistent with each lesson plan and behavior objective.
- Design learning activities that promote analytical thinking skills.
- Create an e-Learning course that interacts with the simulation.
- Design worksheets and achievement tests.

The research tool includes an interactive e-Learning course using the Edpuzzle program, as shown in Fig.1, a video clip integrated with simulation based learning using the Camtasia program, as shown in Fig.2, and a quiz for measuring analytical thinking

skills using the Microsoft Google Forms. Managing MIAP based learning and teaching of e-Learning course, as shown in Fig.3, was implemented in an online classroom for encouraging learners to participate in learning activities as much as possible.

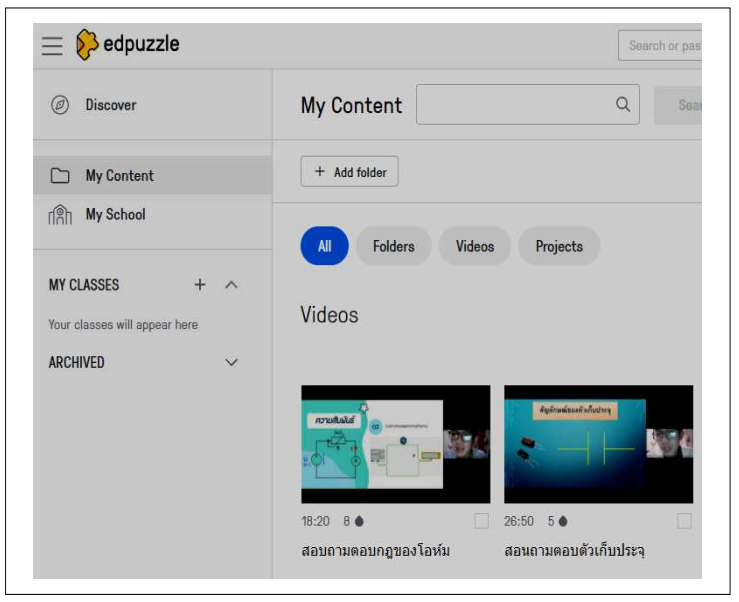

Fig.1. Interactive e-Learning course using the Edpuzzle

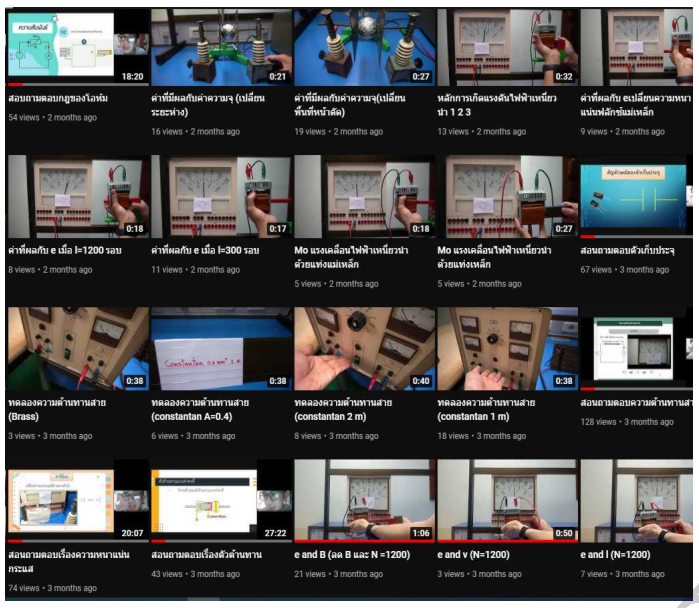

Fig.2. Video clip integrated with simulation based learning

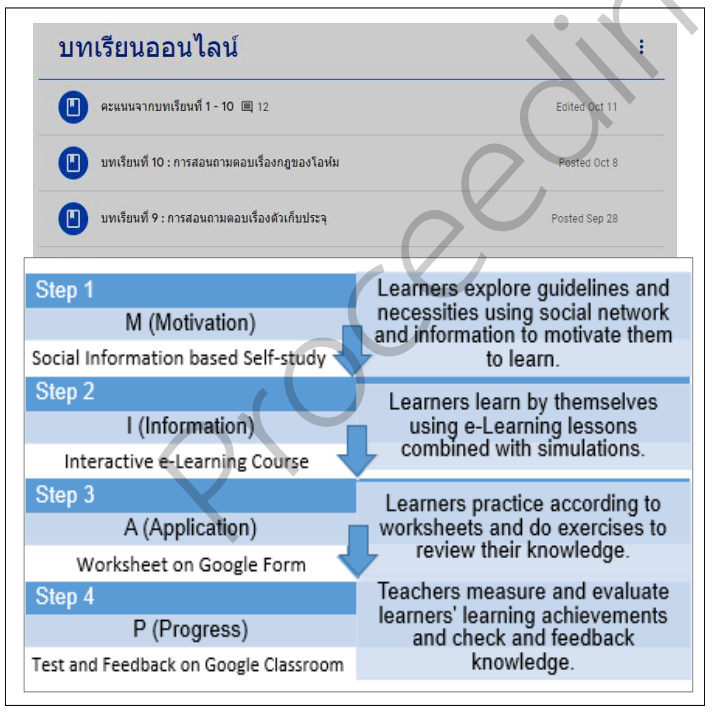

Fig.3. On-line MIAP teaching using e-Learning course

C. Evaluation of quality of research tools

The designed e-Learning course were assessed for quality the suitability of the lessons using five experts. The suitability assessment was found to be good. Research tools have been improved according to the advice of experts and then experimented with small groups of students in order to develop and improve research tools to have quality within practical standards.

D. Implementation with sample group

The research tools were developed using with a sample of 2nd academy year of undergraduate students in electrical engineering at King Mongkut's University of Technology North Bangkok. The sample group was selected with a total of 26 students in the 1/2021 semester year with self-learning and teacher' mentoring and coaching which took a total of 10 weeks to learn.

IV. Research Results

This research is to develop interactive e-Learning course using simulations to enhance the analytical skills of the student teacher. After testing with a sample by doing a single group experiment test before and after learning, then the results were analyzed statistically. The mean, standard deviation, and the assessed results can be summarized into 3 parts as follows:

A. The analysis results of course efficiency

The efficiency analysis result of the interactive e-Learning course using simulations developed to enhance the analytical thinking skills of student teachers found that the E1/E2 efficiency was 82.22/83.74, which was higher than the 80/80 criteria consistent with the research hypothesis, as shown in Table 1. The student's analytical thinking was assessed both before and after learning, as shown in Table 2, where the calculated t-value was 15.57 compared to the t-value at the statistical significance level of .01, and df = 25, which gave a value of 2.485. Therefore, it was concluded that the post-test analysis scores of the interactive e-learning course using simulations-based were higher than the pre-test with statistically significant at the .01 level.

TABLE I. Developed e-Learning efficiency (N=*26)*

Quiz set	Full score	Average score	Efficient (%)
Quiz at the end of the lesson (E1)	115	82.22	82.22
Achievement Test (E2)	35	29.31	83.74

TABLE II. The results of the students' pre- and post-study analytical thinking scores (N=*26)*

Test type	t-test for learning achievement assessment				
	Mean (Max=35)	SD.	df	t score	Sig. (1-tailed)
Pre-test	11.54	2.21	25	15.57	0.0000
Post-test	29.31	5.28			

B. The results of the analysis of students' opinions

After implementing the simulation-based interactive e-Learning course to develop teachers' analytical thinking skills, students' opinions are assessed by using a 5-level assessment scale questionnaire, the assessment results were

presented in Table 3, indicating that learners' opinions on simulation-based interactive e-Learning course were at high appropriate with the mean of 4.26 and a standard deviation of 0.69, the students agreed that management of the simulation-based interactive e-Learning course can provide a good understanding of the MIAP teaching process as well and can be used as a teaching prototype for effective teaching practice.

TABLE III Assessment of students' opinions (N=26)

Evaluated topics	$\overline{X}$	S.D.	Interpret
The e-Learning course section			
1. Help learners understand teaching technique.	4.31	0.62	high
2. Help learners develop their teaching skills.	4.35	0.75	high
3. Help learners understand the course content.	4.38	0.57	high
4. Encourage learners understand the elements of a lesson plan.	4.27	0.72	high
5. Help students understand the techniques and methods of creating presentation materials.	4.08	0.74	high
6. Help learners understand the MIAP process.	4.42	0.70	high
7. Encourage learners understand how to motivate and create interest in the lesson.	4.27	0.58	high
8. Encourage learners understand how to use the digital video material for teaching.	4.31	0.74	high
9. Encourage learners to understand how to use simulation programs for teaching.	4.15	0.67	high
10. Encourage learners understand how to write symbols and electrical circuit elements	4.12	0.71	high
11. Can be used as a learning prototype for teaching practice.	4.42	0.58	high
12. The course topic content is sufficient.	4.42	0.64	high
Testing, measurement and evaluation section			
13. The test is of reasonable difficulty.	4.27	0.72	high
14. The number and type of tests are appropriate.	4.27	0.78	high
15. The quiz has clear and legible questions.	4.12	0.91	high
16. The quiz is consistent with lesson content.	4.27	0.67	high
17. Assessments have established appropriate measurement methods.	4.00	0.75	high
18. The assessment covers the teaching and learning process.	4.19	0.69	high
19. The assessment corresponds to the aims of teaching and learning in course.	4.35	0.63	high
Mean score	4.26	0.69	high

V. CONCLUSIONS

This research presents the development of an interactive e-Learning course integrated with simulation. Interactive e-learning management using simulations that are as close as possible to real teaching situations to encourage students to understand the methods and techniques of teaching of electrical engineering correctly. Students analyze theories and teaching principles for a thorough understanding. Therefore, learners have knowledge and analytical thinking skills that can be applied in lifelong learning. As well as being able to encourage students to have higher learning achievements, similar to the research of Dararat [6] that has developed teaching lessons using computer-aided simulations to develop students' analytical thinking. Supawan's research [3] studied the learning effect of multimedia lessons on simulation of the students' analytical thinking ability, it can be seen that the learners have the ability to think critically at a higher level. The assessment of students' opinions in the Interactive e-Learning course using simulations, it was found that the learners had a high level of satisfaction (mean 4.26 and standard deviation was 0.69), consistent with Supawan's research [3] that simulated multimedia lessons had an impact on students' ability to think critically. This allows them to understand complex content and can be used as a teaching model and practical problem solving [8] which is consistent with Thanakorn's concept [9], states that simulation-based learning management enables learners to experience virtual practice in a safe environment for their learning. As results, Learners can also practice repeatedly until they acquire the skills they need and give the learners a more learning experience.

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P02361

Designing and Building a Basic Programming Logic Controller (PLC) Kit for Teaching in the Programmable Logic Controller Course for Bachelor of Industrial Education Program

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Abstract

Research on a basic programming logic controller (PLC) kit designing and creation for teaching in the programmable logic controller course here resulted from the recognition on problems related to the lacking of testing kit as a teaching material in the programmable logic controller course of the Electrical Department, Faculty of Industrial Education and Technology. Researchers conducted this research to design and create a basic programming logic controller (PLC) kit for teaching in the programmable logic controller course.The sample group in this study was 20 of

students from the second year of the Electrical Department. Data analysis was done to retrieve the percentage, average, and standard deviation values, as well as to compare the learning achievement by t-test. It was found from the results that the experts agreed with the quality of a designed and created basic programming logic controller (PLC) kit at very high level. Teaching by this basic programming logic controller (PLC) kit allowed the group of student samples to have higher learning achievement at the statistically significant level of .05. The group of samples also satisfied with a designed and created basic programming logic controller (PLC) kit at highest level.

Keywords— *Industrial Education, Programmable Logic Controller, Educational programs*

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***Abstract*— Research on a basic programming logic controller (PLC) kit designing and creation for teaching in the programmable logic controller course here resulted from the recognition on problems related to the lacking of testing kit as a teaching material in the programmable logic controller course of the Electrical Department, Faculty of Industrial Education and Technology. Researchers conducted this research to design and create a basic programming logic controller (PLC) kit for teaching in the programmable logic controller course.**

The sample group in this study was 20 of students from the second year of the Electrical Department. Data analysis was done to retrieve the percentage, average, and standard deviation values, as well as to compare the learning achievement by t-test.

It was found from the results that the experts agreed with the quality of a designed and created basic programming logic controller (PLC) kit at very high level. Teaching by this basic programming logic controller (PLC) kit allowed the group of student samples to have higher learning achievement at the statistically significant level of .05. The group of samples also satisfied with a designed and created basic programming logic controller (PLC) kit at highest level.

***Keywords*— Industrial Education, programmable logic controller, Educational programs**

I. INTRODUCTION

The application of control system technology in industrial works is rapidly expanding. As a result of changes, the application of control systems in industrial works has been integrated into teaching and learning process [1]. To encourage the educational institutions to produce and develop quality vocational manpower, the Bachelor of Industrial Education Program, Electrical Department has arranged for the Programmable Logic Controller course which is a subject to study and practice on the application of the Programmable Logic Controller to control on the process of Programmable Logic Controller operation.

A basic programming logic controller (PLC) kit should be adopted as the teaching material for students to practice and obtain knowledge and skills in Programmable Logic Controller usage. However, educational institutions at present still lack of teaching material to make students understanding on the content and enhance their learning. [2] [3]

Therefore, from the background and significance of problem, the researchers aware on the guidelines and approaches for problems solution. Thus, a basic programming logic controller (PLC) kit has been designed and created to be a teaching material in the Programmable Logic Controller course in order to arrange for the effective teaching and learning activities. This would help the learners achieve better learning results from their study and practice on a basic programming logic controller (PLC) kit that the researchers designed and created to be the teaching material for the students. The learners can bring knowledge and experience from this Programmable Logic Controller course to study further in higher level or in their future career. [4] [5]

II. OBJECTIVES

- To create a basic programming logic controller (PLC) kit to be a teaching material in the Programmable Logic Controller course
- To find out for the efficiency of a basic programming logic controller (PLC) kit
- To seek for the results of students' achievements after learning with a basic programming logic controller (PLC) kit
- To find out for the students' satisfaction toward a basic programming logic controller (PLC) kit

III. REARCH SCOPE

A. Scope of a basic programming logic controller (PLC) kit design and creation

The operation teaching materials requires to be properly designed and built in a way that conforms

with the content in the Programmable Logic Controller course. A basic programming logic controller (PLC) kit consists on the following controller kits: lamp control unit, Star-delta motor control unit, and the control unit from sensor.

B. Scope of research samples

Samples were 20 of second year students from the Electrical Department selected by purposive sampling method to test and measure on the result of learning achievement and assess on satisfaction toward the testing kit.

C. Scope of research variables

Independent variable is teaching by a basic programming logic controller (PLC) kit in the Programmable Logic Controller course.

Dependent variables were

- Quality of a basic programming logic controller (PLC) kit
- The efficiency of a basic programming logic controller (PLC) kit
- Students' learning achievement after learning by a basic programming logic controller (PLC) kit
- Learners' satisfaction toward a basic programming logic controller (PLC) kit

IV. RESEARCH METHODOLOGY

A. Design and Creation of a basic programming logic controller (PLC) kit is as follows:

1) Studying on any basic information related to the Programmable Logic Controller: Studying on the researches related the creation of a basic programming logic controller (PLC) kit, a design had taken into account the practice of program writing skills to control the operation of the programmable logic controller for the ease of use and testing kit mobility.

2) Designing the structure and layout of kit materials: The design had broungt the materials from the programming logic controller (PLC) kit to install on the board of testing kit and designed to have various control units such as the lamp control unit, Star-delta motor control unit, and the control unit from the sensor

3) Preparing materials used in a basic programming logic controller (PLC) kit creation

4) Creating a basic programming logic controller (PLC) kit based on designed

B. Experiment and Data collection

1) Finding results of students' learning acheivement from the testing kit and the experimental worksheet from the group of student samples.

2) Evaluation of students' satisafction toward the use of testing kit.

C. Data Analysis and Research Statistics

1) The analysis on the students' learning acheivement from a basic programming logic controller (PLC) kit : Data analysis brought the results from the performance assessment of each lecturer or the expert to analysze. Statisticals used in data analysis were the average and standard deviation.

2) Analysis on the efficiency of a basic programming logic controller (PLC) kit: to seek for the efficiency of the testing kit, the researchers used E1/E2 criteria which was an approach to indicate the efficiency of the teaching material kit in overall. It could give the wide and subsection details in each objective in which allowed the researchers to obtain clearly results and to be the data for determination. The criteria used was E1/E2 = 80/80

V. RESULTS

A. Results of creation and finding quality of the programming logic controller (PLC) kit

1) The characteristics of a basic programming logic controller (PLC) kit for teaching and learning in the Programmable Logic Controller course consisted of 3 control units as follows:

- lamp control unit
- Star-delta motor control unit
- the control unit from sensor

2) Results of a basic programming logic controller (PLC) kit quality finding: quality of a basic programming logic controller (PLC) kit had been evaluated by three experts. The results of quality assessment were as follows:

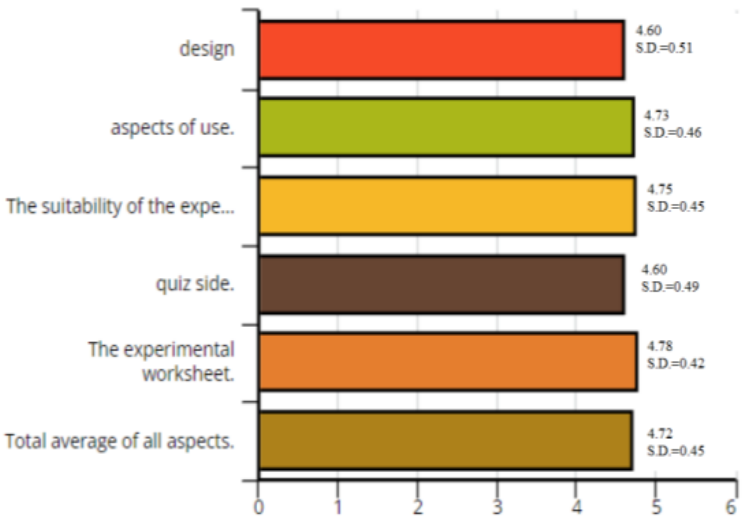

Chart 1: Average values from the quality assessment of a basic programming logic controller (PLC) kit by the experts

From the chart, it is found that overall the experts see that the designed and created programming logic controller (PLC) kit by the researchers has very high level of quality with the overall average of 4.72.

B. Students' learning acheivements from programming logic controller (PLC) kit

Table I. Analytical table comparing the students' learning achievement with the programmable logic controller experimental kit.

Score	Number of learners	Full score	Average	S.D.	t-Stat	t-Critical
Pre-test	20	20	7.45	2.26	24.36	1.729
Post-test	20	20	17.45	1.32		

According to the table, it can be concluded that the sample group of students learning with the programmable logic controller experimental kit shows with higher learning achievement at the statistical significance of.05 when comparing with the values in the table of T-test.

C. Analysis results on the efficiency of a basic programming logic controller (PLC) kit

TABLE II. *Analytic results of a basic programming logic controller (PLC) kit efficiency finding based on criteria of 80/80*

Pre-Test Quiz and Experiment Worksheet			Post-Test Quiz			E1/E2
Full score	Average	E1	Full Score	Average	E2	
10	8.11	83.33	20	17.45	87.45	83.33/87.25

As can be seen from the table, the average score from Pre-test Quiz and experimental worksheet E1 is 83.33. The average score from Post-test Quiz E2 is 87.45 in which higher that the criteria set at 80/80. It can be summed that a designed and created basic programming logic controller (PLC) kit has the efficiency based on the criteria requirement.

D. Results of analysis on sample students' satisfaction toward a basic programming logic controller (PLC) kit

Chart 2 : Average values from the quality assessment of a basic programming logic controller (PLC) kit by the experts

VI. CONCLUSION, DISCUSSION, AND RECOMMENDATIONS

A. Research conclusion

1) The overall quality of a basic programming logic controller (PLC) kit was in very high level at the average of 4.72 and standard deviation value of 0.45. Therefore, the quality of a basic programming logic controller (PLC) kit was in line with the hypotheses.

2) Teaching by a basic programming logic controller (PLC) kit allowed the student samples to reach toward higher learning acheivement at the statistical significance level of .05.

3) A designed and created basic programming logic controller (PLC) kit had higher efficiency than the criteria required at 83.33/87.25.

4) The group of sample students were satisfied with the teaching and learning by a basic programming logic controller (PLC) kit. Overall, the satisfaction level was very high with the average value of 4.74 and standard deviation was at 0.44.

B. Discusion of results

1) The quality of a designed and created basic programming logic controller (PLC) kit was effectively conformed to the defined citeria at very high level. This was higher than the hypothesized level, thus, because of

- A basic programming logic controller (PLC) kit was a teaching material designed and created in systematic way. Its quality had been tested by the experts before testing with the sample group of students.

- A basic programming logic controller (PLC) kit was provided with a manual to help the users understanding more on the working system of the kit. Moreover, the learners could use the kit by themselves just reading from the manual.

2) The results of learning acheivement by the sample group of students who learnt from a basic programming logic controller (PLC) kit showed to have higher acheivement at the statistical significance level of.05. Thus, it could be from the reasons that

- A basic programming logic controller (PLC) kit was a new learning experience for the learners, therefore, the learners paid attention to learn from the content all the time.

3) The sample group of students were satisfied with a basic programming logic controller (PLC) kit at very high level. Thus, this could result from the reasons that

- A basic programming logic controller (PLC) kit allowed the learners to understand more on the content and method to use the Programmable Logic Controller and could apply it in reality.

• The sample group of students could try on a basic programming logic controller (PLC) kit by themselves and it was a full practice on the operational skill.

C. Reccomendations

1) Reccomendations for applying the research results

• It is recommended to design and develop the basic programming logic controller (PLC) kit to use in more diverse operational practices for the learning diversity of the learners.

2) Reccomendations for future research

• It is recommended to design and develop the basic programming logic controller (PLC) kit that can be used online such as forming the virtual experiment kit, etc. for the learners to be able to learn and practice their skills every time and everywhere.

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Case-Based Online Training for Improving Visual Inspection Capability of Employee in Electronic Manufacturing

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Abstract

Many different types of PCB defects can occur throughout the printed circuit board assembly process. The procedure of quality control is essential. A human inspection is important to ensure that the PCBA is delivered in excellent condition. It is critical to train QC employees to understand PCBA inspection standards to determine which PCBAs are acceptable. High rates of PCBA reject, even though the defects are acceptable to the customer, will have an impact on production costs. To improve Quality control performance, the development of decision-making skills of PCBA visual inspection employees was researched. Because to the COVID19 situation, case-based training was provided via online tools. However, in order to clear up any misunderstandings and conduct PCBA inspection tests, face-to-face discussion was still needed. In addition, the trained QC employee's performance was measured using attribute gauge repeatability and reproducibility, which indicated that the QC employee's decision-making

capability had increased. When compared to appraisers before training and standard respectively, employee inspection performance was 11.94 % and 5.69 % better.

Keywords— print circuit board assembly, quality control, decision-making, attribute gauge repeatability and reproducibility, visual inspection

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Case-Based Online Training for Improving Visual Inspection Capability of Employee in Electronic Manufacturing

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***Abstract*— Many different types of PCB defects can occur throughout the printed circuit board assembly process. The procedure of quality control is essential. A human inspection is important to ensure that the PCBA is delivered in excellent condition. It is critical to train QC employees to understand PCBA inspection standards to determine which PCBAs are acceptable. High rates of PCBA reject, even though the defects are acceptable to the customer, will have an impact on production costs. To improve Quality control performance, the development of decision-making skills of PCBA visual inspection employees was researched. Because to the COVID19 situation, case-based training was provided via online tools. However, in order to clear up any misunderstandings and conduct PCBA inspection tests, face-to-face discussion was still needed. In addition, the trained QC employee's performance was measured using attribute gauge repeatability and reproducibility, which indicated that the QC employee's decision-making capability had increased. When compared to appraisers before training and standard respectively, employee inspection performance was 11.94 % and 5.69 % better.**

Keywords*— *print circuit board assembly, quality control, decision-making, attribute gauge repeatability and reproducibility, visual inspection

I. INTRODUCTION

Usually, high-quality products are required from electronics manufacturing services because of small size and high-resolution. Optical inspection with image processing machine is used as the main method for print circuit board assembly (PCBA) inspection. However, double inspection by human is necessary in order to recheck incorrect inspection obtained from the machine. The QC employee will judge whether this PCBA is good (OK) or not good (NG). The NG PCBA was divided to 2 types as following : 1) PCBA with defect which effects to quality of PCBA function and 2) the PCBA with small defect which is not effects to quality of PCBA function. The QC employee needs to split the second types of NG PCBA and change it to G PCBA instead. Therefore, precisely inspection effects to cost reduction of PCBA production.

Training of QC employees to clarify inspection criteria is essential therefore precisely inspection can be obtained. In this paper, case study-based training with online tools was introduced to enhance PCBA inspection and decision-making skills for quality control employees. Utilization of online tool prevents spread of COVID19. Because of utilization of online tools, case study lesson can be easily and often updated then it was sent to QC employee to learn through mobile device. This is the main advantage for PCBA inspection because new kinds of defect can occur every day. Mechanism of PCBA inspection via online tools was explain. Attribute gauge repeatability and reproducibility (GR&R) was used as indicator for performance of training and stand for decision-making of QC employees.

II. IMPROVEMENT VISUAL INSPECTION CAPABILITY BY CASE-BASED TRAINING

A. Printed Circuit Board Assembly visual inspection

Printed circuit board assembly final testing may pass in dynamic method or by automation system done, and often use the two methods together to achieve. "Manual" refers to an operator use optical instrument through the visual inspection board to make the right judgment about defect.[1] The operator must use decision-making skill for judgment about defect follow the inspection criteria are set by customer and Institute for Interconnecting and Packaging Electronic Circuits standards for acceptable or unacceptable Printed circuit board assembly.

B. Case-based Learning

The case method bridges theory to practice, and promotes the development of skills. Case method means the analysis of realistic economic, managerial, and other situations in order to teach participants certain skills during the discussion of the case, including through the training of other participants. Decision-making skill enhancement is suitable for case-based learning because criteria of decision usually was learnt and set from large number of cases. [1-3]

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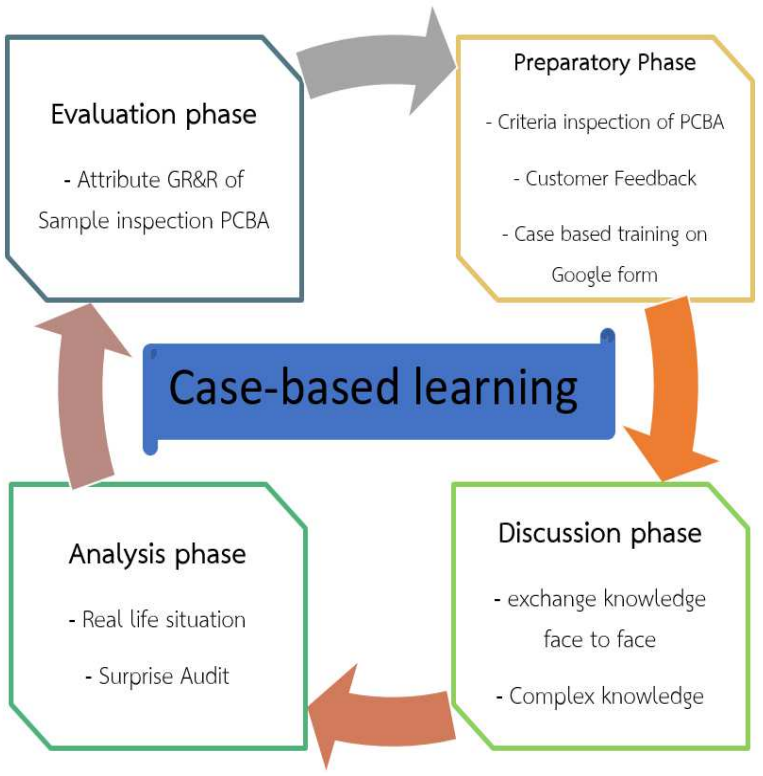

Fig. 1. Case based Learning process

The proposed idea of case study-based training process which this program is focused on criteria of PCBA inspection. Given the versatility of case-based instruction, there are many teaching configurations that instructors might employ. However, the sequence of preparation and analysis usually occurs as follows: [4]

1. Preparatory phase: Create online lessons by Google Form.The section explains the visual inspection standards for PCBA. Inspection course was divided into three lessons: 1) PCB defect 2) component defect and 3) soldering defect. In each lesson, it was split into smaller topics with illustrations of unacceptable and acceptable sample found in production process and obtained from customers' feedback. We sampled 21 employees in the visual inspection position from one shift to train and were required to examine the good and not good of PCBA sample before learning. Shuffle PCBA sample of 50 pcs. were used in this process. The result of inspection will used as reference before train for GR&R evaluation.

2. Discussion phase: Trainees spent studying time the case so that they are well familiar with the facts and content. All trainees need to participate in the training via Google form, where the trainer will provide them each 1-3 topic every day. At the end of lesson, trainees need to take an exam for used as information for discussion phase. Online training is flexible in content modification and convenient in learning because learners can study without limitation of time and place. Furthermore, it can reduce daily meeting therefore employees will start working more faster than usual and it can also reduce possibility of spread of COVID-19 occurred during meeting.

Trainer summarizes the knowledge gained in each lesson. Face-to-face meeting was organized at the end of the lesson. Examination data obtained form google was analyzed and clarify in the face-to-face meeting. Real defect PCBA was shown in order to relate the learn concept to practical.

3. Analysis phase: Because the training lasts around two weeks. Employees are thus taught to analyze the PCBA in the process. There is a trainer who audits employees' work and allows the employees to raise questions or ask inquiries in order to ensure confidence in the separation of good PCBA or not good PCBA. Moreover, in each lesson participants are required to take a paper-based test. Trainee was required to decide whether the PCBA is good or not good from picture. The test were only 10 questions in each lesson. This information just confirm that all trainees were clearly understand.

4. Evaluation phase: Trainees were required to inspect sample piece of defect and non-defect PCBA. The PCBA sample of 50 pcs. were inspected within 5 mins. And each trainee was required to inspect 2 times with shuffle order of sample. We compared the kappa values before training and after training of all 21 trainees by attribute GR&R to determine the effectiveness of case-based training to enhance decision-making skills for PCBA inspection.

C. Attribute Gage Repeatability & Reproducibility

Before, collecting and using data to make decisions about any process or product (Printed Circuit Board Assembly), it is important to verify that the measurement system is good enough by doing a Measurement System Analysis.[6]

Most problematic measurement system issues come from measuring attribute data in terms that rely on human judgment such as good/bad, pass/fail, etc. This is because it is very difficult for all testers to apply the same operational definition of what is "good" and what is "bad." **.** [7]

For GR&R evaluation, it is important to verify that the measurement system is good enough therefore the evaluation criteria was set as following:

- Specify the criteria of evaluation based on GR&R method.
- Obtained 50 random PCBA samples from a regular production.
- Selected trainee who usually performs the inspection activity regularly.
- Performed the 50 random PCBA sample inspection by each trainee for 2 times before and after training.

We use Kappa value a measure of agreement between appraisers and appraisers with standard can be found by using Cohen's kappa value.[8]

Kappa is calculated using the following equation:

$$k = (p_o - p_e) / (1 - p_e) \qquad (1)$$

After the finish evaluation, the results should be documented and stored in a database for future reference. If any issues should arise, a new study can be performed on the gage and the results compared to

the previous data to determine if a change has occurred.

In this research study, form Measurement Systems Analysis of Automotive Industry Action Group we define to the decision criteria of attribute GR&R shown in table I.

TABLE I. DECISION CRITERIA [9]

Indices	Perfect	Excellent	Need to improvement	unsatisfied
Within appraisers	Kappa =1	1>Kappa >0.8	0.8> Kappa >0.6	Kappa <0.6
Each appraiser vs. standard	Kappa =1	1>Kappa >0.8	0.8> Kappa >0.6	Kappa <0.6
Disagreement G/NG	0%	>2%	2-5%	>5%
Disagreement NG/G	0%	1-10%	10-15%	>15%

III. IMPLEMENTATION

The proposed program was implemented at Cal-Comp Electronics (Thailand) Co., Ltd. For quality control employee development, the visual inspection process was employed as a case study. This training program drew in twenty-one quality control employees. The training schedule was specific; they would train every day and hold three meetings after each lesson's training was completed. All trainees were required to do a before and after training test and the result of the test were evaluated with attribute GR&R.

IV. RESULT

The results were processed with the help of the Minitab software. Form fig. 2, the results show that decision-making skill background of QC employees were not much difference and they are at average because it has not much difference between the comparison within appraisers and with standard.

And possibility of totally defect inspection of PCBA was more precise. The average value of disagreement of good PCBA and not good PCBA were 6.67% and 3.43% respectively. Therefore, the total loss is higher than 10%.

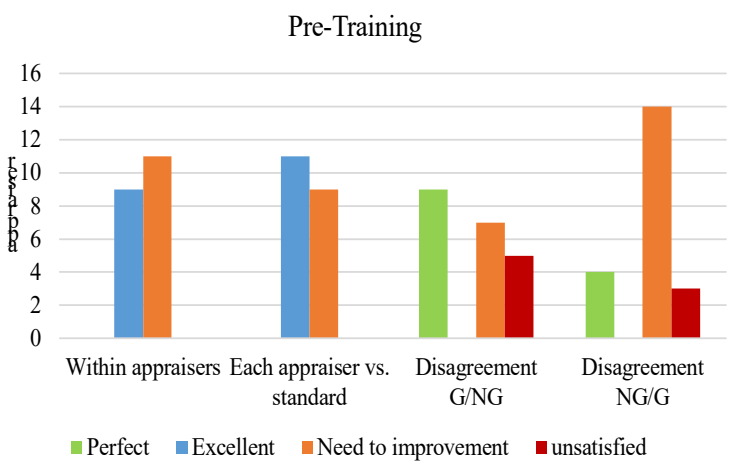

Fig. 2. Result of GR&R evaluation obtained from before trianing.

TABLE II. GR&R EVALUATION RESULT OF EACH APPRAISER BEFORE TRAINING

Appraiser	Within Appraisers	Each Appraiser vs Standard	Disagreement	
	Kappa	Kappa	G / NG	NG/ G
Appraiser_A	0.636364	0.819591	0%	0%
Appraiser_B	0.718988	0.859494	0%	0%
Appraiser_C	0.793303	0.777446	0%	12%
Appraiser_D	0.79798	0.739302	8%	8%
Appraiser_E	0.919872	0.879952	4%	4%
Appraiser_F	0.718988	0.779768	0%	8%
Appraiser_G	0.918831	0.879421	0%	8%
Appraiser_H	0.79798	0.738182	8%	8%
Appraiser_I	0.879566	0.819784	4%	8%
Appraiser_J	0.878788	0.859575	0%	8%
Appraiser_K	0.799277	0.69935	12%	8%
Appraiser_L	0.879566	0.819784	4%	8%
Appraiser_M	0.838969	0.839744	0%	8%
Appraiser_N	0.839744	0.879872	4%	0%
Appraiser_O	0.879952	0.779944	8%	8%
Appraiser_P	0.958661	0.818475	0%	16%
Appraiser_Q	0.758454	0.759615	4%	8%
Appraiser_R	0.719888	0.819736	4%	0%
Appraiser_S	0.714402	0.738495	0%	12%
Appraiser_T	0.758454	0.758969	8%	4%
Appraiser_U	0.840000	0.840000	4%	4%

Disagreement G / NG: Appraiser judgment Good PCBA but standard is Not Good PCBA.

Disagreement NG / G: Appraiser judgment Not Good PCBA but standard is Good PCBA.

From Table II, highest of disagreement of good PCBA and not good PCBA is up to 16%. It was just only 2 persons who provided the precisely inspection results. Disagreement of not good PCBA was the critical decision. It means that almost all of QC employees cannot examine the good PCBA with the acceptable defect.

Fig. 3 shows the result after training. It is shown that inspection capability of QC employees were above average which it can be trusted that precisely inspection can be obtained. The average value of disagreement of good PCBA and not good PCBA were1.90% and 0% respectively.

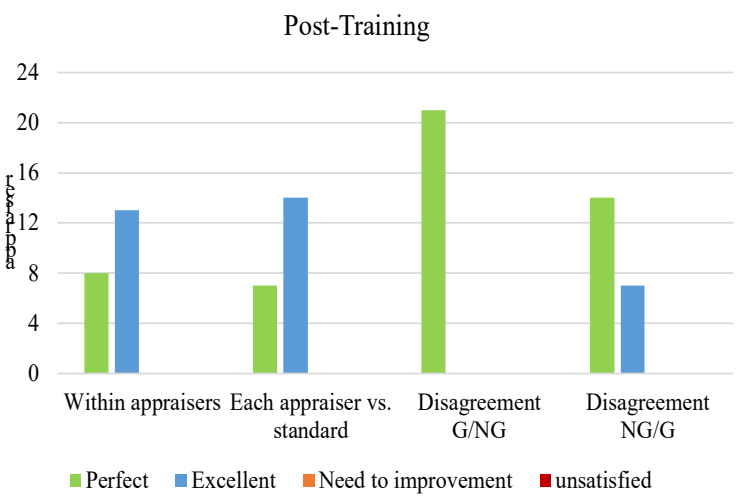

Fig. 3. Result of GR&R evaluation obtained from after trianing.

TABLE III. GR&R EVALUATION RESULT OF EACH APPRAISER AFTER TRAINING

Appraiser	Within Appraisers	Each Appraiser vs Standard	Disagreement	
	Kappa	Kappa	G / NG	NG/ G
Appraiser_A	0.95998	0.97999	0%	0%
Appraiser_B	1.00000	1.00000	0%	0%
Appraiser_C	0.75649	0.83858	0%	4%
Appraiser_D	0.79928	0.85980	0%	4%
Appraiser_E	1.00000	1.00000	0%	0%
Appraiser_F	0.91987	0.95994	0%	0%
Appraiser_G	1.00000	1.00000	0%	0%
Appraiser_H	0.87760	0.85893	0%	8%
Appraiser_I	1.00000	1.00000	0%	0%
Appraiser_J	1.00000	1.00000	0%	0%
Appraiser_K	0.75649	0.87825	0%	0%
Appraiser_L	0.87995	0.93998	0%	0%
Appraiser_M	0.79928	0.89964	0%	0%
Appraiser_N	1.00000	1.00000	0%	0%
Appraiser_O	0.75962	0.87995	0%	0%
Appraiser_P	0.91883	0.87957	0%	8%
Appraiser_Q	0.87879	0.89948	0%	4%
Appraiser_R	1.00000	1.00000	0%	0%
Appraiser_S	0.87879	0.89948	0%	4%
Appraiser_T	0.75649	0.87825	0%	0%
Appraiser_U	1.00000	0.91987	0%	8%

From Table III, highest of disagreement of good PCBA and not good PCBA is reduced to 8%. However, QC employees were still a lit bit of examine the good PCBA with the acceptable defect.

In comparison between before and after training, QC employee inspection capabilities were improved. Occurred of disagreement was reduced to less than 2%. However, QC employees were usually confusing in disagreement of good PCBA.

In the weeks after the training completed, the study was performed again using 50 of the original Printed Circuit Board Assembly, with the results presented in Fig.3 and table III. This study shows that the inspection process was improved substantially.

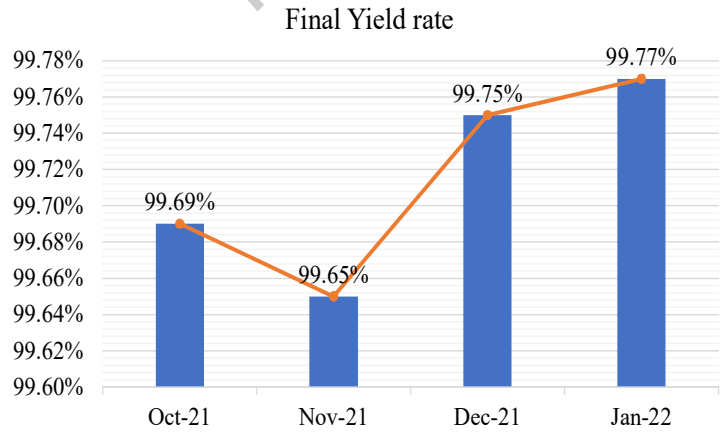

Fig. 4. Final Yield rate inspection

The final yield rate inspection in Fig. 4 is compared to the months before training in October and November. December and January are the months completing training. Because QC employees' incorrect judgment of Good PCBAs to Not Good PCBAs has decreased, the final yield inspection has increased, as seen in the graph.

V. CONCLUTION

This paper improves the decision-making skills of quality control employees indicates that case-based training can improve the quality control worker's decision to check the printed circuit board. The result showed that the inspection performance of employees calculate with average value was better than 11.94% and 5.69% compared to appraisers before training and standard respectively. This means that the quality control employee's job capability was increased. The products that were delivered to customers were of good quality. In addition, the company's wasteful costs could be reduced. To ensure long-term, effective employee skill control, case studies and GR&R testing should be updated periodically.

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P02352

Development Innovation-based Learning Model to Study the Creation of Teaching Media for Students of Technical Education Program

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Abstract

The purposes of this research were: 1) to develop an innovation-based learning model for creating teaching materials of technical education students, 2) to study the effect of using an innovative- based learning model for the study of creating teaching materials of the technical education students. The Sample groups of the research were 28 the third-year students with a bachelor's degree in Technical Education, Department of teacher training in electrical engineering at King Mongkut's University of Technology North Bangkok (KMUTNB), the research instruments include with 1) the developed innovation- based learning model, 2) the lesson plan using an innovative-based learning model, 3) assessment form for innovation media, and 4) a student satisfaction assessment form. The research results shown that 1) The results of the assessment of the suitability of the innovative-based learning model by experts were appropriate at a high level (mean = 4.36 and S.D.= 0.55), 2) The results of the students' assessment of the skills in

creating teaching materials on electrical of the learners which passed the criteria at 70 percent and 3) Learners' satisfaction of the developed innovative learning model at a highest level (mean was 4.56 and the standard deviation was 0.68).

Keywords– Innovation-based Learning

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***Keywords*—** *Innovation-based Learning.*

I. INTRODUCTION

National Innovation Agency (NIA), Thailand has given the meaning of innovation that means new things arising from the use of knowledge and creativity that is beneficial to the economy and society. The key elements of innovation include: 1) novelty, 2) usefulness, and 3) use of knowledge and creative thinking. The process of creating innovation works is as follows steps: 1) searching 2) selection 3) implementation and 4) learning. Nowadays is the 21st century era that focuses on technology adoption used in the education to manage teaching and learning to be effective and increase learners' learning achievements. The learners' skills in the 21st century include: 1) learning and innovation skills, 2) information, media, technology skills, and 3) life and occupation [1], where innovation is important greatly to the current study because the globalized world is changing rapidly in every aspect, that focuses on advances in technology and information, therefore education needs to evolve from the old education system to the modernization of technology and social conditions. [2].

From the results of the country's reform plan for the year 2019 found that education management is inconsistent and responsive to the changes in the country in the 21st century where digital technology and innovation plays an important role, this reflects that teaching and learning according to the curriculum alone may not be enough. Therefore, applying appropriate research and learning model are essential to encouraging students to apply their knowledge and skills to apply in practice that is consistent with learning in the 21st century.

Innovation-based learning is a learning style that encourages learners to develop innovations themselves and promotes the learning development of learners throughout the period of innovation development, as a result, students understand the process of innovation and develop creative thinking skills, systematic thinking skills, problem solving skills, decision-making skills, leadership skills, and teamwork skills, etc. which is skills of innovators. [3]

The Innovation and Instructional Media subject is a course in the bachelor's degree in Electrical Engineering and Education program, Department of teacher training in electrical engineering, Faculty of Technical Education at King Mongkut's University of Technology North Bangkok (KMUTNB) which provides teaching and learning to educate and train learners' skills in creating innovative instructional media, the condition of teaching and learning was found that 1)the students still lacked the thinking process in creating new educational innovations and 2) Students create projects that still lack innovation. Therefore, the researcher has an idea to encourage learners to create innovative skills in an instructional media, which developed an innovative-based learning model for education in the creation of teaching media.

A. Purposes of the research

1. To develop an innovation-based learning model for the study of the creating teaching media of the technical education students.

2. To study the effect of using an innovation-based learning model for the study of creating teaching media of the technical education students.

A. Research hypothesis

1. Innovation-based learning model for the study of creating teaching media of the technical education students were appropriate at a high level.

2. Learners had a score of skills in creating teaching medias in the electrical field at 70 percent.

3. Learners' satisfaction with developed innovation-based learning model at a high level.

II. Learning and Teaching Theory

A. Innovation-Based Learning

Innovation is bringing new things such as ideas, actions, inventions into changes or additions from old methods for better usability. The characteristics of innovation that have been attracted and used widely are as follows: 1) not complicated 2) not expensive 3) readiness for use 4) innovation that does not affect the original product 5) concrete and clear.

Learning innovation is facilities that enable teachers to design learning management with focus on student-center, students are exposed to various situations which will lead to learning, inventing, and practice, resulting in skills and expected features, Innovations for learning management that are good for teachers should be innovations that are easy to use, useful and do not affect traditional learning methods which can be divided into *2* types: 1) Different types of learning materials and 2) Techniques and methods of learning [4]

III. Implementation

This research was experimental research with the one sample group to validate the efficiency of the innovation-based learning model. The research methods were as follows:

A. Defining a sample group

The sample group was 2nd year bachelor's degree students in Electrical Engineering and Education, Department of Teacher Training in Electrical Engineering, Faculty of Technical Education at King Mongkut's University of Technology North Bangkok (KMUTNB). There were 28 students enrolled in the innovation and instructional media subject that selected using a purposive sampling.

B. design of online learning model

The researcher has studied the relevant data and research, then design an innovative-based learning. The process of developing innovation in teaching and learning using 5D innovation development process, the steps of the innovation development process using 5D Innovation Development Process, which has the following steps:

1) Step 1 (discover): Instructor defines the topics and key points of innovation media for learners to search and invent innovations related to media used for teaching and learning in electrical and electronics.

Fig.1. Discover step by 5W1H method

2) Step 2 (design): Students design the structure of innovative learning media in electrical and electronic fields.

3) Step 3 (develop): Learners create an innovative prototype media for electrical and electronic learning as designed in step 2

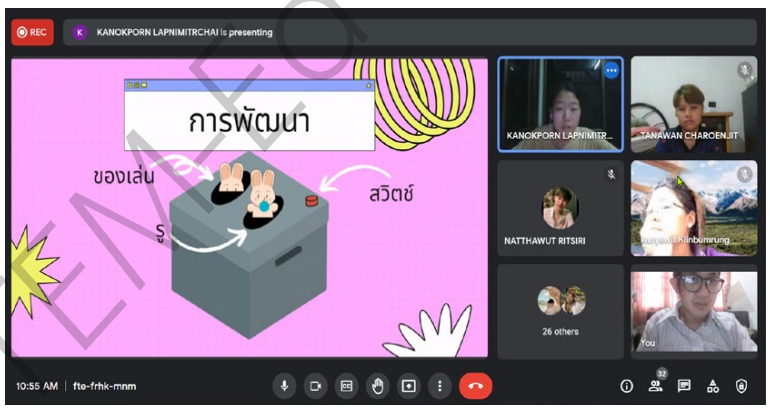

Fig.2. Design and Develop step

4) Step 4 (deploy): Students publish the work in media form such as posters, presentations, AR media, video etc.

5) Step 5 (drive): Summary of the results of the trial and disseminating innovative media for used teaching and learning in electrical and electronics

Fig.3. Example for deploy step with augmented reality (AR) media

C. Development of research tools.

The researcher creates and develops the research tools used for research. The research tools consisted of 1) the developed innovation-based learning model, 2) the lesson plan using an innovative-based learning model, 3) an innovative media assessment form, and 4) a student satisfaction assessment form.

D. Finding the quality of research tools.

The quality assessment of the designed innovative-based learning model which assessment from 5 experts found that the results of the suitability assessment were at appropriate at a high level, the researcher improve the research tools and then try out with a group that is similar to the sample group which test the effectiveness of the research tool for implement with sample group

E. Try out with a sample group.

The researcher used the improved research tools try out with a sample group which 28 students with a 2nd year bachelor's degree in Electrical Engineering and Education, Department of Teacher Training in Electrical Engineering, Faculty of Technical Education at King Mongkut's University of Technology North Bangkok (KMUTNB). Selection using a purposive sampling in Semester 2/2021, duration of learn 5 weeks (5 hours/week)

IV. Research Results

This research is the development of an innovation-based learning model. After that experimenting with the sample group, the results were statistically analyzed such as mean, standard deviation which can summarize the research findings into 3 parts as follows:

A. The quality results of developed innovation-based learning model.

The quality assessment of the developed innovative-based learning model which assessment from 5 experts who teach teaching in innovation and instructional media as shown in table I.

TABLE I. QUALITY OF DEVELOPED INNOVATION-BASED LEARNING MODEL (N=5)

Evaluated topics	$\overline{X}$	S.D.	Interpret
1. Appropriateness of the learning management plan	4.40	0.55	high
2. Appropriateness of the overall elements of the innovation development process	4.60	0.55	highest
3. Appropriateness of the innovation discovery stage	4.60	0.55	highest
4. Appropriateness of the innovative design stage	4.40	0.55	high
5. Appropriateness of the innovation prototype development stage	4.60	0.55	high
6. Appropriateness of the innovation trial stage	4.60	0.55	highest
7. Appropriateness of the summary and follow-up steps	4.20	0.84	high
8. Appropriateness of the tools used	4.40	0.55	high
9. Appropriateness of innovation media assessment items	4.20	1.10	high
10. Appropriateness of teaching and learning activities	4.40	0.55	high
average	4.36	0.55	high

From Table 1, the results of the assessment of the quality of the developed innovative-based learning model on the 5 experts found that the overall assessment results in all topic were appropriate at a high level (mean = 4.36 and S.D.= 0.55)

B. The assessment results of the skills in creating teaching innovative media

The evaluation results for skill in creating teaching innovative media for electrical and electronics. Evaluate topic consist of 1) innovation discovery, 2) Innovative design, 3) Development of innovative prototypes, 4) The use of innovative media for teaching and learning in electrical and electronics and 5) Conclusion of the implementation. Results as shown 14 projects in table II.

TABLE II. THE SCORE OF THE ASSESSMENT IN SKILLS OF CREATING TEACHING INNOVATIVE MEDIA (N=28)

Evaluated topics	$\overline{X}$	Interpret
1. Automatic plant watering machine	80	good
2. Automatic waste bin	87	good
3. Quiz game	85	good
4. Automatic tree care machine	80	good
5. Automatic alcohol sprayer	72	moderate
6. Auto switch via mobile phone	79	moderate
7. Cat toy	86	good
8. Alcohol dispenser	74	moderate
9. Pet food machine	81	good
10. Bangle S.O.S.	84	good
11. Smart vacuum cleaner	78	moderate
12. Smart mail box	89	good
13. Document sterilizer	76	moderate
14. Smart thermometer	73	moderate
Average	**80.3**	good

From Table II, the students' evaluation results of the skills in creating teaching innovative media for electrical and electronics were average equal to 80.30 which passed the criteria (70 percent).

D. The analysis results of students' satisfaction.

The students take a satisfaction assessment at the end of the teaching process with an innovation-based learning model, the questionnaire using 5-level rating scale shown in table III.

TABLE III. The results students' satisfaction. (N=28)

Evaluated topics	$\overline{X}$	S.D.	Interpret
1. Help learners to seek knowledge by themselves as well.	4.63	0.61	highest
2. Help students to combine knowledge in many fields together.	4.5	0.73	highest
3. Help support lifelong learning	4.5	0.81	highest
4. New and interesting learning style.	4.63	0.61	highest
5. Help learners take responsibility for assigned tasks.	4.56	0.62	highest
6. Stimulates the creative thinking process of learners.	4.75	0.57	highest
7. The learning activities are fun and not boring.	4.25	0.85	high
8. Learners gain a wide range of knowledge.	4.63	0.61	highest
9. Learners are able to apply the skills they have acquired for project work and media in other subjects as well.	4.60	0.63	highest
10. Learners have developed their own learning potential better than normal forms of learning.	4.56	0.72	highest
Average	4.56	0.68	highest

From Table III, the students' satisfaction on innovation-based learning model at a highest level (mean is equal to 4.56 and S.D. is equal to 0.68), when considering the topic, it was found that the learners had satisfaction on the stimulates the creative thinking process of learner's topic with the highest level of satisfaction (mean is equal to 4.75 and S.D. is equal to 0.57),

V. CONCLUSIONS

This research aims to develop an innovation-based learning model for creating teaching materials of technical education students. The research found that 1) the quality results of developed innovation-based learning model was appropriate at a high level which mean = 4.36 and S.D.= 0.55, 2) The students' evaluation results of the skills in creating teaching innovative media for electrical and electronics with a average total is equal to 80.30 which passed the criteria at 70 percent and 3) the learners had satisfaction on an innovation-based learning model at a highest level 4.56 and S.D. is equal to 0.68, that is consistent with the research of Paradorn[3], studies the effect of innovation-based learning on twenty-first century skills and learning experiences among nursing students, the results showed that the twenty-first century skills score after the experiment was higher than before the experiment in the experimental group ($p<0.05$). Additionally, the twenty-first century skills score in the experimental group was higher than the control group ($p<0.05$). The experimental group was at a high level for learning experiences with innovation-based learning (mean= 4.01, S.D. = 0.01). Therefore, the innovation-based learning (IBL) can be promoted learning skills in twenty-first century and learning experiences should be used as a guideline of extracurricular activities and developing innovative production processes

ACKNOWLEDGMENT

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P02330

Expanding Student Engineering Experience Through Building an Astromech Droid

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Abstract

In this work, we outline the start of a project to expand engineering interest at our campus robotics club: the development of an autonomous Star Wars astromech robot. This project involves students from various undergraduate engineering majors and the overall goal of this project is to adapt our autonomous navigation software stack into a new robot that will be constructed over the next 2 academic years. During Fall 2021, a large number of the students arriving on campus were new, many of whom had not stepped on campus before. We use this project to aid in student development – both technically and in their acclimation to campus life. The student club lost many upperclassmen during the 2020-2021 academic year and we outline how we organized the newer students into functioning groups.

Keywords—

Expanding Student Engineering Experience Through Building an Astromech Droid

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***Abstract*—In this work, we outline the start of a project to expand engineering interest at our campus robotics club: the development of an autonomous Star Wars astromech robot. This project involves students from various undergraduate engineering majors and the overall goal of this project is to adapt our autonomous navigation software stack into a new robot that will be constructed over the next 2 academic years. During Fall 2021, a large number of the students arriving on campus were new, many of whom had not stepped on campus before. We use this project to aid in student development – both technically and in their acclimation to campus life. The student club lost many upperclassmen during the 2020-2021 academic year and we outline how we organized the newer students into functioning groups.**

I. Introduction

We present a case study into a project-based learning experience where undergraduate students participate in the construction of an Astromech droid from the Star Wars [1] series of movies. This robot project serves as a platform where students from various engineering majors can participate in building a familiar design while gaining hands-on experience.

The robotics club at California Polytechnic State University, San Luis Obispo, USA, serves as an extracurricular club where undergraduates can gather to work on various robotics projects. Past projects have included underwater ROVs, an autonomous golf cart, and other small robotics projects. Club members consist primarily of undergraduate engineering majors where the most common are mechanical, electrical, and computer engineering majors along with computer science.

During the COVID lockdown of the 2020-2021 academic school year, the club switched to virtual meetings. As a result, there was reduced progress on actual projects themselves during this time. In this paper, we outline an effort after the lockdown year to rejuvenate the robotics club at our university through a project to develop an autonomous Star Wars [1] astromech robot. A sample image of an astromech droid is shown in Figure 1. While we expect this to be a multi-year project, this is an effort that started in Fall 2021 and continues at the time of writing of this paper. The focus of this paper is to document the impact of the project on the students returning to in-person instruction on our university campus and to describe the benefits the project has provided to the engineering education at the campus robotics club.

This paper is organized as follows: Section II outlines prior work that is related and relevant to this project. Section III

Fig. 1: A sample astromech image from the astromech.net builders' club brochure [2]

outlines the background material regarding astromech robots, the technical aspects of our design, and budgetary information. Section IV covers the experience of running this project in our robotics club. Section V concludes.

II. Related Work

Various work has shown the benefit of a university extracurricular robotics club in both student technical knowledge growth and in student interaction [3], [4]. These prior works mention several benefits such as peer-to-peer learning, exposure to technologies not covered in class, and fruitful social interaction with peers.

Karp et al. [5] provide an introduction into the construction process of an astromech droid. This work covers the different materials, electronics, and motors used in model astromech droids. Causer [6] covers the process of adding emotion and character to an astromech running in an amusement park. This work also covers the challenges of building the robots to be robust in the presence of changing environments.

Work that is similar in spirit to our work is described by Lara-Prieto et al. [7] where the authors use a Star Wars droid as an educational tool. In that work, authors describe having groups of first year engineering students participate in a workshop initially working with a commercial BB-8 radio controlled droid and then eventually, the students build a functioning prototype. The prototype is at a smaller scale than the movie design, but the prototype rolls and functions as expected. That work highlights the enthusiasm that is

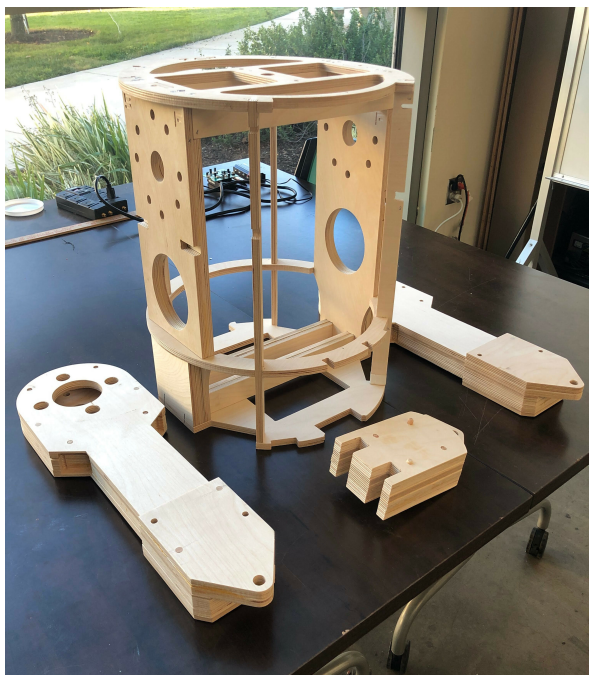

Fig. 2: Photograph of the student-assembled wood frame and wood legs. The diameter of the cylindrical main body is approximately 46 centimeters.

brought about when working with recognizable robots and we experience the same.

Additional Star Wars inspired educational academic projects include: Star-force [8] (a mixed reality simulator employing haptic feedback and augmented reality) and using Star Wars to teach recursion in programming courses [9].

III. Astromech Droids

Astromech droids are robots portrayed in the Star Wars series of movies. R2-D2 is the most famous and iconic astromech droid, and BB-8 is another well-known example. Members of the R-series of astromech droids are cylindrical in shape and approximately 1.0 meter tall with a diameter of 46 centimeters. Because of the complexity involved in constructing a rolling, spherical robot, such as BB-8, we choose to target a standard 3-wheel R-series astromech. A sample image of an astromech droid can be seen in Figure 1. Although similarly styled, the astromech droids themselves come in various color schemes and configurations.

Many movie fan builders have constructed astromech droids, but because of licensing restrictions with Disney [10] and Lucasfilm [11], fan builders are not allowed to offer a complete astromech kit for purchase. While the trademark owners of the astromech droid designs do not allow the sale of complete and movie-accurate model kits, the companies do allow the hobbyists to construct replica parts and sell those parts to other builders.

The primary knowledge source for astromech building information is the online forum: http://astromech.net. The forum was founded in 1999 and on this forum, builders can purchase parts, download plans for wood frames and 3D-printable components, and discuss with other builders in general. At the time of writing, the forum has over 2,000 active members worldwide.

A. Construction Process

Because there is no reference construction kit for an astromech droid, there is a fair amount of background research

Fig. 3: Photograph of the current members and astromech dome of the astromech development project.

that needs to be performed before proceeding. Due to the robot parts being low volume items, some parts are fabricated by hobbyists only on an as-needed basis. This means that some parts are built in part runs, where parts are fabricated once a sufficient number of buyers are interested. Because of this, there is a fair amount of planning and scheduling for part procurement.

The droid frames can be constructed of aluminum, wood, styrene plastic sheet, or 3D-printed parts. Frames are the inner support for the cylindrical aluminum skin and are not visible once the robot is complete. We desire a frame that can easily be constructed without specialized tools and thus we select wood for our frame material. Available on the astromech forum are plans describing how to CNC a wood frame from plywood. Instead, we opt to purchase the pre-cut Tex-Mex wood frame [12] as shown (after assembly) in Figure 2. This frame is CNC routed from Baltic birch plywood and the pieces are of high quality. For the dome, we choose an aluminum part which is lasercut with the appropriate openings. This can be seen in Figure 3. The aluminum skins are the externally visible aluminum shell that defines the iconic look of an astromech. We select ones that are pre-curved and have lasercut panels.

The robot is driven using a 2-wheel differential drive configuration with a third leg in a caster setup. In the Star Wars movies, astromechs can switch from an upright, 2-wheel configuration to an angled 3-wheel stance. This transformation is quite complex to implement when building an actual functioning robot so we opt to build a fixed 3-wheel configuration. The drive motors are standard Neo brushless motors [13] from high school robotics competitions.

B. Autonomous System Design

For this astromech, we adopt a navigation framework that is available to us at our university and it is based on the ROS Navigation Stack [14]. This navigation system is already functioning on another existing robot. The sensor configuration for the two robots is the same, a single monocular camera for sensing. We do not delve into detail into the operation of the system in this work, but we will provide an overview of the system sensing and actuation requirements.

In terms of autonomous navigation, the goal of the project is to have the ability to autonomously navigate an outdoor quad area in between 2 university buildings. This is an area marked by clearly delimited sidewalk areas and grass areas. This known area is subdivided into linear segments that can be classified by the neural network running on the robot.

Because of the desire to have a similar look to a movie-spec astromech droid, a primary goal is to minimize the number of externally visible sensors. Our in-house navigation system uses a single monocular camera (M12 lens size) to obtain 640x360 HDR color images to perform obstacle detection, coarse robot localization (at the granularity of hallways), and path planning. Neural networks are used to perform these tasks on a per-frame basis. The single camera can be hidden near or potentially behind one of the decorative astromech ports (becoming visible with a flip-up servo). Our target is to have the camera located in the upper of the 2 horizontal gray ports located in the midsection of the R3-A2 astromech shown in Figure 1.

The computer system runs an embedded Ubuntu Linux distribution and contains a multi-core ARM CPU with a 512-core GPU for running the neural networks. Given our current neural network architecture, a single inference pass takes on the average 30ms.

In terms of support electronics, we use a custom Arduino shield with encoder counting hardware and RC receiver interface circuitry. This shield is shown in Figure 4. The robot is powered using RC-car style 4S lithium-polymer batteries (6000mAh) and for manual control by a human operator, we select a standard RC-style transmitter.

C. Budgeting

The construction of an R-series astromech can be a quite expensive project and the overall cost varies greatly on the type of build material, with aluminum being the most expensive.

The most expensive non-electronic component is the hemispherical aluminum dome. This a quality component that can only be sourced from one vendor. After the dome, the frame and the drivetrain components are the most expensive parts. In terms of components for compute and autonomy, we use the NVIDIA Jetson AGX Xavier as our primary embedded computer, which typically retails for $699 USD and is currently much more expensive due to current shortages. Fortunately, we are able to utilize the NVIDIA board from a previous project.

IV. Experience

In this section, we outline the process of recruiting students to join the club, organizing them into an effective engineering team, and managing aspects of the robot construction process.

A. Student Recruitment

The typical process of student recruitment for the club is for the current club leaders to attend the campus club fair at the beginning of the school year. At this event, the club leaders gauge student interest and contact freshmen that

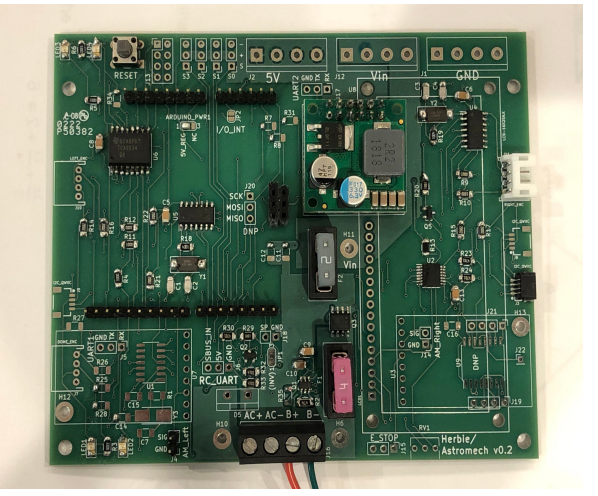

Fig. 4: The custom designed controller board for the project. The board functions as a large Arduino shield.

have already arrived on campus. During this most recent club fair in the post-lockdown academic year, the makeup of interested students included incoming freshmen, incoming transfer students (those who had studied 2-years at a local community college), and junior-level students who had only partially completed their freshman year in-person in the 2019-2020 academic year. Because this was the return to in-person operation of the campus, it was evident that there was great interest in students to become involved in extracurricular activities after being separated from each other during the 2020-2021 academic year.

B. Student Experience

The first two club meetings involved presenting the current projects to the new club members. During these initial meetings, the makeup of students was approximately 85% new members and 15% returning upperclassmen members. This was a marked difference to prior years, where the fractions of new and return members were approximately equal. This was not particular to the robotics club in the university, and was a university-wide phenomenon.

As can be imagined, there was a substantial amount of interest and excitement for the project and it was a practical challenge to get the incoming students organized into productive groups. For the project, students were divided into 3 teams: mechanical, electrical, and software. During this initial quarter, there were 3 returning upperclass students who were able to function as team leads for the mechanical and software groups. The faculty advisor served as the lead for the electrical group. It was noted that a number of the incoming freshmen had experience in high school working on teams building robots for competitions such as FIRST robotics [15]. At the same time, many of these students had their high school competitions canceled the previous academic year due to COVID.

With the large percentage of new club members that are freshmen and given the fact that this is a new project in the club, there are challenges to be expected. The first challenge is that it is difficult to expect incoming freshmen to commit to a project while they are getting acclimated to the university academic environment and college culture in general. For many of the students, upon arriving at a new school, they are

learning which extracurricular activities to participate in and how to balance their academic workload. During the beginning of the first academic term, the average student attendance for the teams was as follows: mechanical (˜7 students), electrical (˜5 students), software (˜10 students).

During the past few months of the project, there have been many observed successes within the astromech project. Various freshmen and new transfer students have developed practical skills in woodworking, surface-mount soldering, programming microcontrollers at the register level, and working with ROS recording files. In addition to the technical skill growth in students, the club project has provided an environment where these new students can meet others, build friendships, and take a step towards a typical, post-COVID educational environment. The technical skills of some of the students has been quite impressive and this project has been a true motivator in that growth.

With any project involving many students, there will always be challenges present. One of the initial challenges was the distribution of work for students. In particular, the software group often felt a lack of direction because of the delay in having an actual functioning platform to test on. This is a problem that arises in many robotics projects that involve hardware engineering before software development can be done. Our problem is not unique and the solution involves guiding students to develop software background knowledge while the hardware is being engineered. A second problem is that separating the members into one of the three technical groups can lead to students feeling locked in to that particular area. This can be addressed with periodic checkins with each member to assess how the student is feeling about their work on the project.

C. Survey Results

In Table I we show results of a student survey regarding the impact of the project on their impression of the engineering field. The questions were: (Q1) *I have learned engineering ideas and practices that I have not learned in class* and (Q2) *The project has helped to confirm (or disprove) I have selected the appropriate major*. We find that students report favorably that the project has exposed them to engineering concepts that they would otherwise not cover in the classroom and this is a primary goal of our project. Students also report favorably on Q2 which probes whether students feel they have selected the correct engineering major. Additionally, 83.3% of the students reported that working on the project has confirmed their interest in engineering.

Question	Results (5-point Likert scale, 5=strongly agree)
I learned engineering ideas and practices that I have not learned in class (Q1)	4.5
This project has helped to confirm (or disprove) I have selected the appropriate major (Q2)	4.5

TABLE I: Student survey results.

V. Conclusion

In this work, we describe a project at our university robotics club to expand engineering education through building an autonomous Star Wars astromech droid. Our project goal is an R-series astromech body style. This project started in the academic year after the COVID lockdown of 2020-2021. We use this project as a way to motivate freshmen and other incoming students to participate in engineering extracurricular activities. The students that arrived on campus at the beginning of the 2021-2022 had missed an entire year of in-person instruction and this is an opportunity to engage those students in engineering outside of class.

We find that the students have varying degrees of robotics experience with several of them having had their high school robotics club canceled because of the COVID lockdown. During the initial months of this longer term project, students are successful in learning practical engineering skills that they might otherwise only pick up in their later years of college.

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Working to reduce the gender gap in STEM fields in Spain. A project based on mentoring and participation

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Abstract

The low presence and participation of women in Spain, in studies and professions linked to some STEM fields (Science, Technology, Engineering and Mathematics) is a transgenerational reality, despite the good academic results of women in science and technology. This vocational segregation has aroused the interest of the international scientific community over the last forty years, but there is hardly any research in our country that approaches the study of gender biases in different STEM professions by young people throughout the different stages of transition to adult life.

Keywords— STEM, ALAS, women, scientific-technologic vocations, Spain

Working to reduce the gender gap in STEM fields in Spain. A project based on mentoring and participation

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***Abstract*— The low presence and participation of women in Spain, in studies and professions linked to some STEM fields (Science, Technology, Engineering and Mathematics) is a transgenerational reality, despite the good academic results of women in science and technology. This vocational segregation has aroused the interest of the international scientific community over the last forty years, but there is hardly any research in our country that approaches the study of gender biases in different STEM professions by young people throughout the different stages of transition to adult life.**

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I. INTRODUCTION

Between 2005 and 2015, STEM (Science, Technology, Engineering and Mathematics) employment grew by nearly 25% – over five times more than non-STEM employment over the same period. During 2020, STEM jobs have grown by almost 11%, compared to the other industries that grew by 8%. Jobs related to computer science, mathematics, engineering, life and physical sciences are projected to grow up to 49% by 2029.

This demand for STEM jobs is going to mean an increase in the need of academic specialization in STEM areas. Nowadays, there is a low presence and participation of women in studies and professions linked to STEM field. This low presence of women can have negative consequences that prevent them from developing in an increasingly competitive professional environment.

According to the data offered by the Spanish Ministry of Universities in its 2021 report [1], in the University Entrance Exams (UEE), the percentage of women enrolled with respect to the total was 56.5% compared to 43,5% of men. Of all the women enrolled in the UEE, 88.5% passed the tests, compared to 88% of men. Of all enrollments in university degrees, 55.61% are women. Specifically, in the branch of Engineering and Architecture, it is where there is less homogeneity, since 74.9% of those enrolled and 72.7% of graduates were men.

Then, from these data we obtain that of the total number of enrollments in university degrees, only 4.42% corresponds to women enrolled in the Engineering and Architecture branch. Figure 1 shows a graph with the data mentioned above.

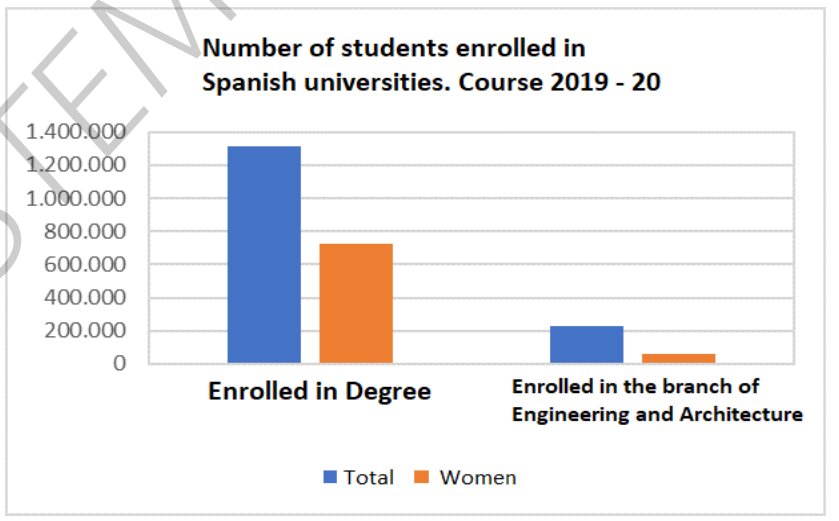

Figure 1. Number of students enrolled in Spanish universities. Course 2019-20.

If at the national level the percentage of women compared to men in the field of Engineering and Architecture is 25.14%, at the University of Huelva it drops 10 points, dowing to 15%. Even in some engineering areas, female enrollment is 0%.

Due to the need to carry out clear, concrete and concise actions on the previously presented data, the ALAS (Accompanying girLs towArds STEM careers) project is located. This project aims to develop a study based on a multi-model theoretical foundation, which allows identifying the causes, making decisions and avoiding the current and very low participation of women in STEM careers. The objectives are:

1. Application of Expectancy–Value Theory of Achievement Motivation [2].
2. Application of the Motivational Theory of Role Modeling [3].
3. Application of the multicomponent model of gender stereotypes [4].

II. ACCOMPANYING GIRLS TOWARDS STEM CAREERS

ALAS project aims to carry out a study that includes three models over the four stages: primary education, secondary education, higher education and the first years of incorporation into working market. The objective is to examine the factors that explain a greater or lesser presence of women in STEM occupations.

To prepare this study, it will be necessary to visit educational centres of primary, secondary, high school and higher education. Once in the educational centres, a speech about motivation and professional opportunities is given to students. After this, a survey is distributed. The survey addresses key questions to understand this gender gap in some STEM fields. Among these issues, highlighting the perception of young people about what STEM occupations and people are like, the reasons that have led them to choose STEM studies and occupations, or the difficulties they perceive regarding the access and progression of women in these occupations.

Once the students have fill in the survey, a series of practical activities (participatory workshops) will be developed in educational centres. These workshops aim to show and bring students closer to women who have studied STEM careers. The women play a mentoring role and they teach the workshops in the scientific areas of their specialty. The purpose is to reduce the harmful effects of gender bias for the achievement of a society based on equal opportunities for men and women.

A. Research development

Based on the starting hypothesis and the data presented in the previous section, the general objective of this project is to examine explicitly and implicitly the gender barriers and biases that students perceive and that have an impact on the four educational stages: primary education, secondary education, high school and university. The students who have graduated from the university and they have entered the labour market are also analysed. To carry out this study, the three models mentioned above will be used: "Expectancy–Value Theory of Achievement Motivation", "Motivational Theory of Role Modeling" and "Multicomponent model of gender stereotypes".

The survey that students fill in, is structured as follows; it is divided into three constructs, and each construct is related to each model mentioned above. Similarly, each construct is made up of a series of questions/items that allow the model to be analysed. Figure 2 shows a general outline of the structure of the survey.

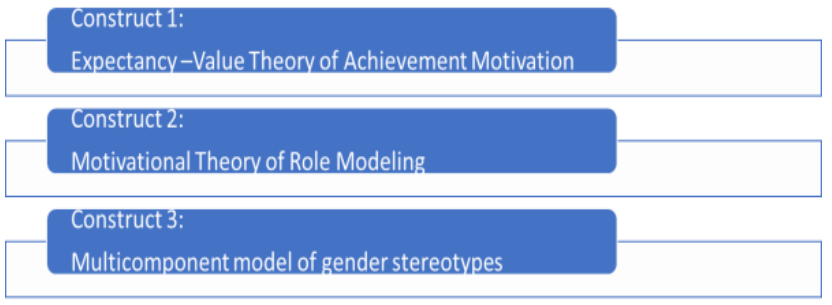

Figure 2. General outline of the distribution of constructs in the surveys.

The structure of the survey is explained in more detail below. "Expectancy-Value Theory of Achievement Motivation" [5] will be made up of three blocks that will eventually be joined together to form a construct. The first block is defined by Pintrich & Groot [6]. They state that there are three important categories for the study of school motivation: 1) The goals and intentions with which the student is involved in the performance of a task; 2) Perceived competence, and 3) The affective-emotional reactions produced in him/her. The second block is defined by Bandura [7], which distinguishes between the expectation of efficiency, where the individual has the belief that can perform a task, and the expectation of result, where a given action leads to a given result. Finally the third block is defined by Leifheit [8] where it is evaluated whether students' motivation and self-concept can be reliably assessed by incorporating computer science education at an early age and how to teach the tools in programming in a motivating way. Motivation and self-concept have been found to be important predictors in the areas of mathematics and science.

In order to be able to analyse this model, the three previous blocks will be taken into account, which together will form the first construct. Each block is made up of a series of items that will allow us to carry out the analysis of the model. Figure 3 shows an example of the items introduced in secondary education level.

	1 (Totally disagree) – 2 – 3 – 4 – 5 (Totally agree)	Expectancy–Value Theory of Achievement Motivation
The subjects: math, science and technology are fun		Pintrich & Groot
I'm better at math, science, and technology than other peers		
If I try hard in math, science and technology I will learn and get good grades		Bandura
I can study enough to pass the next math, science and technology exam		
Being good at math, science, and technology is important to me		Leifheit
If I know a lot about math, science and technology I will impress my classmates		

Figure 3. Construct 1. Expectancy-Value Theory of Achievement Motivation for secondary education level.

Looking at Figure 3, the question "The subjects: math, science and technology are fun" and "I'm better at math, science, and technology than other peers" relate to the first block, defined by Pintrich & Groot. The question "If I try hard in math, science and

technology I will learn and get good grades" and "I can study enough to pass the next math, science and technology exam" relate to the second block, Bandura. Finally, the question "Being good at math, science, and technology is important to me" and "If I know a lot about math, science and technology I will impress my classmates" relate to the third block defined by Leifheit.

The second construct, based on "Motivational Theory of Role Modeling", argues the roles that society has on men and women, where men are the breadwinners and women are homemakers, as well as the notable differences in status and power. In the same way as the previous construct, in this construct a series of questions were asked in order to analyse this model. Figure 4 shows again the questions from the survey asked to high school students. Among the questions to be highlighted are "Piloting airplanes", "Make the beds", "Sewing" or "Ironing", which will be analysed in section 3.

	Men	Women	Both	Motivational Theory of Role Modeling
Piloting airplanes				Bandura
Make the beds				
Sewing				
Ironing				

Figure 4. Construct 2. Motivational Theory of Role Modeling for secondary education level.

Finally, the third construct, based on the "Multicomponent model of gender stereotypes", aims to examine the stereotypical beliefs and attitudes that young people in secondary education have about people working in the field of information and communication technologies (ICTs) [4].

	1 (Totally disagree) – 2 – 3 – 4 – 5 (Totally agree)	Multicomponent model of gender stereotypes
Girls are better at studying humanity's careers (such as: Languages, History, Teaching ...) tan boys"		Leifheit
Boys are better at studying science-related careers than girls. (Example: Computer Science, Electronics ...)		
Girls are more organized and collaborate better with other people than boys		

Figure 5. Construct 3. Multicomponent model of gender stereotypes for secondary education level.

In order to analyse this construct, a series of questions were asked, as shown in Figure 5. Questions such as "Girls are better at studying humanity's careers (such as: Languages, History, Teaching ...) tan boys", "Boys are better at studying science-related careers than girls. (Example: Computer Science, Electronics ...)" or "Girls are more organized and collaborate better with other people than boys".

B. Selection criteria

- Guidelines for selecting the target educational centres

The criteria to select educational centres was public centres distributed along the geography (province, north and south of country, and international). For this purpose, Huelva province (at the south of Spain) has been divided into 6 areas as shown in Figure 6. These areas are: "Sierra", "Andévalo", "Cuenca minera", "Condado", "Costa" and "Huelva province". Authors have selected a primary and secondary school from each area.

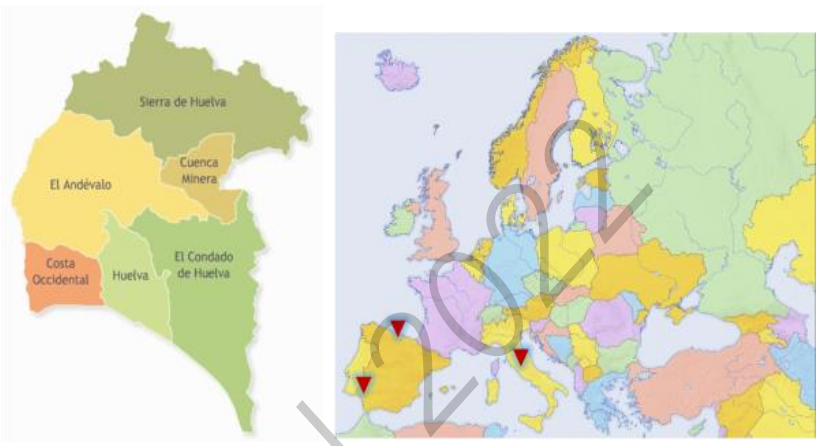

Figure 6. Geographical location of visited educational centres: Spain (Huelva in the south and País Vasco in the north), and Italy (Rome).

As shown in Figure 6, we also intend to carry out a visit education centres from the north of Spain (Basque Country Vasco), in order to evaluate whether the geographical difference between the north and south of a country influences the teaching method, and whether this has a behavioural impact on the student. In the same way, we also have carried out the study in another country. Italy has been selected because of its cultural and social similarity with Spain. The aim of these visits is to compare the level of teaching between two European countries and whether this also influences students' perceptions.

- Guidelines for selecting the target students

The criterion for primary school students will be set for students in the last two years. Likewise, the criterion for secondary school students will be set for third and fourth grade, as it is the last phase of secondary education. Surveys have also been distributed at the university for multiple disciplines (engineering, education, law, etc.), in order to know the reason students had to be studying the career they chose, and the grade of sensitivity of teacher in relation to gender gap in STEM careers.

C. Framework for creating a data collection tool

The surveys have been printed on paper and filled in by hand in primary and secondary schools, both students and teacher. Alternatively, at university level, both students and teachers have filled in them online. Google Forms survey template has been crated, and authors insert hand-filled surveys answers into Google Forms. This tool allows authors to make data mining from multiple point of views.

III. RESULTS

The results of the surveys in primary education have been carried out by analysing a total of 108 surveys so far. In secondary education have been carried out by analysing a total of 221 surveys so far. Figure 7 shows the results of several questions related to the "Motivational Theory of Role Modeling" in primary and secondary education.

Figure 7. Questions about the Motivational Theory of Role Modeling in primary and secondary education.

Figure 8 shows the questions "Is there a science lab at your school?" and "How many times have you been to the lab since you started school? It can be seen that in primary education, 69.45% of students do not have a science lab at their school, and 97.22% have been to the lab less than 10 times. Similarly, in secondary education, 90.50% of students have a science lab at their school, but only 27.60% have used it more than 10 times.

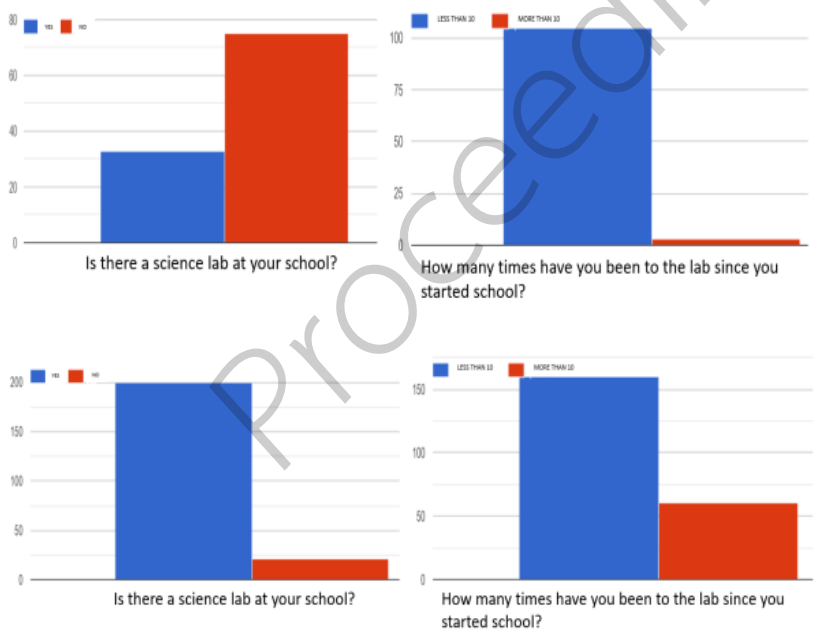

Figure 8. Questions about science lab in primary and secondary education.

IV. CONCLUSIONS

Based on obtained results, a certain tendency towards gender roles can still be seen, especially in household chores, which are passed down from parents to children [9]. In the same way, parents' professions could also be an indicator of impact on the academic decision [10]. Likewise, the teacher plays an important role in the diverse experiences of the students [11]. Teachers' beliefs on gender role could affect children's gender role perceptions and behaviours. For this reason, teacher training programs on equality issues can increase teachers' awareness, in order to provide an unbiased educational environment for male and female students. Teachers not only educate, but also transmit the values, norms, and traditions shared in a society.

As shown in Figure 8, if students at an early age such as primary education do not have resources, in this case science labs, they cannot put the knowledge they are acquiring into practice. Similarly, in secondary schools, most have science laboratories but do not use them. Secondary education is a very important stage because it is here that students have to choose the area of knowledge in which they want to specialise. There is no point in having a laboratory and not using it, because you will not be able to apply the knowledge acquired and they will never be able to choose whether they like STEM subjects.

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