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A COMPETENCY-BASED LEARNING MODEL FOR DISTANCE EDUCATION IN THE POST-COVID-19 ERA: SUSTAINABLE MANUFACTURING SYSTEMS AND THE CIRCULAR ECONOMY

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ABSTRACT

This research aims to: (1) establish a competency-based learning model for teaching and learning about sustainable manufacturing systems and the circular economy, (2) evaluate the model's effectiveness in learning outcomes and (3) investigate student satisfaction with the model for distance education in the post-COVID-19 era. The research tool was based on the ADDIE model regarding concerns about competency-based learning based on 'the four Cs' of critical thinking, creativity, communication, and collaboration. The tools were evaluated by experts and then trialled by the participants for six weeks; then, data were collected and analyzed using mean, standard deviation, t-test, and multivariate analysis of variance. The study's developed learning model, referred to as PADICA, comprises eight elements and six steps of planning, analysis, designing, improvement, confirmation and application that assist the students to succeed academically. The results showed that the students developed competencies in critical thinking and creative skills beyond collaboration and communication, which correlate significantly with years of student experience. Additionally, lecturers and experts have a tremendous impact on students' learning. The PADICA model assists in achieving the results of distance learning by focusing on learning-based competencies, with weekly e-learning by industry needs, that helps gradually build students' learning base and competencies.

Keywords: Competency-based learning; e-learning; distance education; sustainable manufacturing systems; ADDIE model; post COVID-19

1. INTRODUCTION

Since competency-based education has become more prevalent globally, to meet the needs of employers, especially during and in the wake of the COVID-19 period (Banerjee et al., 2019; Efendi et al., 2019; Buheji & Buheji, 2020), graduates require the knowledge, skills, and attitudes that lead to adaptability and the capacity for problem solving (Buheji & Buheji, 2020). In addition, business has changed in the Industry 4.0 era, and both closed and open universities have adjusted their teaching and learning practices to incorporate more

distance learning. Research connected to competency-based learning (CBL) or individual learning [IL] is still difficult, especially with respect to online delivery in science fields such as health sciences (Sistermans, 2020), and computer networking (Efendi et al., 2019). CBL has been applied in training courses, such as a course on paper packaging design (Pankohlerng, 2017), a course on competency-based teaching for sustainable development teaching (Vare et al., 2019), and others. It is clear from the insights gained from these experiences that online instruction should be managed appropriately and in accordance with current best practices.

Universities are crucial in developing competency-based education, which entails the development of knowledge, skills, and attitudes particularly positive ones in order to equip students or graduates with the required initiatives and skills to deal with the 'new normal' (Buheji & Buheji, 2020). These required learning competencies in the industry 4.0 era are 'the 4Cs': critical thinking, communication, collaboration, and creativity (Efendi et al., 2019), therefore it is necessary to create learning models that address the demands of teaching these competencies to students. With this in mind, five open universities (OU5): the University of the Philippines Open University (UPOU), Universitas Terbuka (UT), Open University Malaysia (OUM), Hanoi Open University (HOU), and Sukhothai Thammathirat Open University (STOU)—approved the research project "Building competency-based learning for distance learning in the post COVID-19 era" during a joint meeting on March 2nd and 9th, 2021.

In order to prepare students for the demands of the Industry 4.0 era and the post-COVID-19 world, the research team conducted this study on sustainable manufacturing systems and the circular economy by integrating the material into Course 97706: Engineering Management and Process Development, a Master of Science Program in Engineering Management Technology at the School of Science and Technology, STOU, which was launched on the first semester of the 2021 academic year.

The COVID-19 pandemic led to significant lifestyle changes across the globe, and especially in Thailand. As a result of these changes, society in general, and the education sector in particular, have had to adapt to and embrace a so-called 'new normal'. The policy sector, educational institutions, professors, and students were forced in 2020 to urgently turn to online distance learning to help reduce the risk of spreading or being easily infected by the COVID-19 virus. Traditional face-to-face study sessions were effectively eliminated with no real warning or preparation. In light of the closing of educational institutions, it became necessary to apply distance learning with students.

This study is a research and development design which aims to establish a competency-based learning model for teaching and learning about sustainable manufacturing systems and the circular economy, to evaluate the model's effectiveness in terms of learning outcomes, and to investigate student satisfaction with the model for online learning in the post-COVID era. The foundation for the conceptual framework of this study comprises the information gathered from relevant studies and theories as well as discussions that took place during meetings with the OU5. The framework (Kembara et al., 2019) is centred on assessing students' knowledge, skills, and attitudes to aid in the development of the 4Cs: critical thinking, communication, collaboration, and creativity, as shown in Figure 1. In addition, student background (age, gender, work experience) is included in this research as confirmed by Grande et al. (2021).

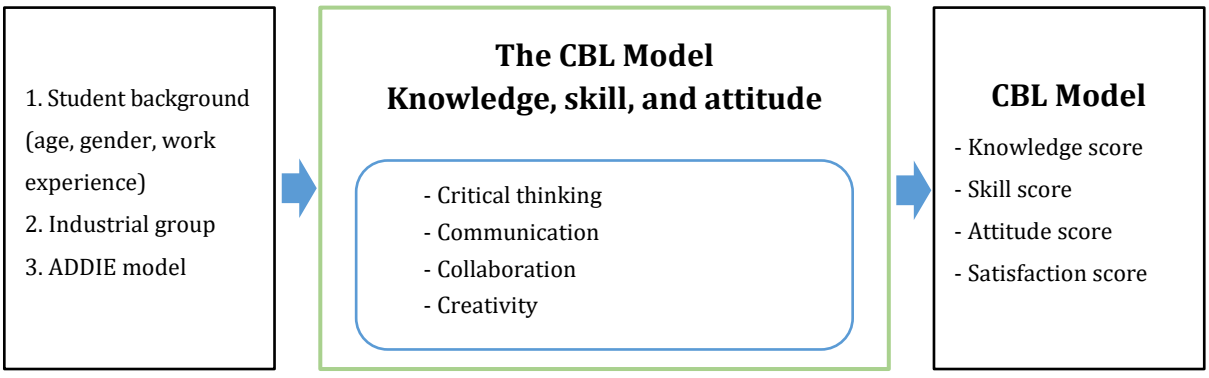

Figure 1: Conceptual framework of the competency-based learning model

2. METHODOLOGY

The research methods mentioned here include population and sample, research tools, data collection and analysis.

2.1 Population and sample

In the first semester of the 2021 academic year, nineteen students were enrolled in Course 97706: Engineering Management and Process Development, a population-wide study created to experiment with learning competency-based models on sustainable manufacturing systems and the circular economy using e-learning media for 6 weeks.

The sample consisted of twelve out of the nineteen students who were able to participate in the activities voluntarily. Only men with 5 to 30 years of work experience were included in the sample group, which covered professional engineers (33.33%), practitioners and technicians (25%), senior managers (16.67%), lecturers (16.67%) and those in unspecified occupations (8.33%).

2.2 Research tools

Research tools consisted of the following:

2.2.1 Learning content

Learning content comprising principles, activities, and activity outcomes was developed. To create this tool, literature on competency-based learning was reviewed; the content in Unit 15 entitled "Sustainable Manufacturing Systems and Circular Economy", Course 97706: Engineering Management and Process Development was created. The instrument was undertaken with expert panels A, B, C and D. The evaluation form underwent a quality evaluation with content validity based on the index of item objective congruence (IOC) by an expert panel A (a CBL expert, a distance education expert, and an instructional media expert). The result must be above or equal to 0.6 to 1.0. If any questions showed IOC less than 0.6, those were adjusted according to the experts' comments before being submitted to the ethics committee.

2.2.2 A draft of the competency-based learning model for distance learning

Expert panel B consisted of five packaging industry professionals with expertise in competency-based learning, sustainable manufacturing systems and the circular economy; they collaborated to develop a draft of the competency-based learning model for distance learning. Using the findings of a brainstorming process, a research team relied on learning content from the first tool: to compile content for the model draft in accordance with industry needs. They also produced a video clip for e-learning, and created activities and developed learning outcomes. The instrument was also verified with content validity, based on IOC with a score above or equal to 0.6 to 1.0, by an expert panel C, composed of five experts in educational media, teaching management and distance education, and the packaging industry.

2.2.3 A competency-based learning model

A competency-based learning model was established which included a learning activity plan and instructional manuals, as well as evaluation tools related to knowledge, skills, attitude, and satisfaction that were modified in accordance with recommendations that arose from the development of the second tool: Expert panel D consisted of three experts in distance education, CBL, and evaluation. They reviewed and evaluated the content validity using IOC (score above or equal to 0.6 to 1.0). The four evaluation tools consisted of the following:

2.2.3.1 The knowledge competency assessment form

The knowledge competency assessment form comprised pre-post-tests with ten questions each that asked about the content of Unit 15: Sustainable Manufacturing Systems and the Circular Economy. This form was used with students.

2.2.3.2 The skill-based assessment form

The skills-based assessment was composed of two forms, using a 5-point Likert scale and a 7-point semantic scale, respectively. The first form was used by experts to evaluate student activities during each week, while the second form was used to evaluate the final project in the sixth week.

2.2.3.3 The attitude performance assessment form

The attitude performance assessment form consisted of 12 questions utilizing a 7-point semantic scale that assessed the learning model with respect to a number of characteristics: interesting, appropriate content, application to real work, critical thinking, collaboration, communication, creativity, application for teaching and learning, ease of understanding, opportunity for practicing, support for presenting and criticizing classmates' work, and enthusiasm and the enjoyment of learning from participating.

2.2.3.4 The student satisfaction assessment form

The student satisfaction assessment form comprised two parts – (1) students' background, and (2) teaching-learning satisfaction in terms of content, format, lecturer, media, and evaluation using a 5-point Likert scale.

2.3 Data collection

This research was conducted in five steps following the ADDIE model (Seels, 1997) and divided into three parts, in line with the research objectives, as follows:

2.3.1 A competency-based learning model development

To develop a competency-based learning model for teaching and learning about sustainable manufacturing systems and the circular economy. For this objective, the ADDIE model's analysis (A) and design (D) processes were used.

2.3.1.1 Analysis

In order to develop an appropriate teaching and learning model for competency-based teaching on sustainable manufacturing systems and the circular economy in course 97706: Engineering Management and Process Development, this step involved analyzing information about the content that was needed to be developed, the desired purpose, and the media to be used. Expert B and three members of the research team participated in the brainstorming process.

2.3.1.2 Design

A competency-based learning model on sustainable manufacturing systems and the circular economy was developed by using the first draft document analyzed from the first step of the brainstorming as a guideline for the second brainstorming with a different group (expert C) and the research team. The purpose of this step was to design activities used for six weeks in e-learning via Microsoft Teams, as shown in Table 1 and Figure 2.

In the first week, the focus was on sustainable manufacturing principles and an overview of this learning to create a mini project. An online whiteboard called Miro, which is a helpful tool for promoting student collaboration, was used to facilitate discussion since it provided students with a platform that allowed them, even though they were physically separate, to freely produce ideas and share resources (Chan et al., 2023). Figure 2 shows how the students collaborated and added add their ideas and discussions, including more details to expand their understanding and knowledge each week of their learning. For example, in the fourth week, the students learnt the concept of the circular economy, and they applied their ideas to the project, as shown in Figure 2. Two videos of 5 to 6 minutes each regarding international and national events were viewed as part of the activities. In order to increase awareness of the value of industrial participation in lessening the effects of global warming, the first story concentrated on the effects of climate change. The second promoted the concept of the circular economy by showing how waste can be recycled into new items. After the students were divided into three groups of four students each, the class viewed a 5-minute video lesson on the principles of sustainable manufacturing systems. After that, students spent around 30 minutes in small groups discussing ideas for mini-projects that included what they had developed whilst using the Miro program to track their progress. Each group then spent about five minutes presenting their proposals.

Each week an industrial expert (expert panel E) offered a 35–40 minutes related lecture and commented on each project. Expert panel E comprised of three professionals drawn from expert panel B who could join a particular class each week. The routine activities of watching the lesson clip, making project presentations, and sharing comments were carried out from the first week until the fifth week. Each week's activity design included activity results related to the 4 Cs, and revisions to the mini projects made in response to feedback from one of the members of expert panel E was presented in the sixth week.

The completed mini-projects relating to sustainable manufacturing systems and the circular economy were presented to expert panel F for evaluation that comprised of three experts in CBL and SMSCE.

Table 1: Content issues and activities each week

Week	Content	Activities	The four Cs Activity results
1	**Principles of sustainable manufacturing systems**	• Teacher increased environmental awareness with the help of videos about global issues. • Students watched a brief 5-minute video clip that outlined the principles of sustainable manufacturing systems. • Students brainstormed in groups of four to develop and present mini-projects based on the concepts of sustainable manufacturing systems. • Students listened to lectures from one of the members of expert panel E and his or her evaluations of the students' projects. • The students revised their projects and then re-submitted them in the following week.	critical thinking and collaboration

Table 1: Content issues and activities each week (continued)

Week	Content	Activities	The four Cs Activity results
2	**Indicators of sustainable manufacturing systems, and examples of their use**	• The teacher played a brief 5-minute video clip summarizing indicators for sustainable manufacturing systems and usage examples. • Students worked in groups of four to come up with additional projects that would apply the right indicators for sustainable manufacturing systems, and then they presented the updated projects. • Students listened to lectures from one of the members of expert panel E and the evaluations of the students' projects. • The students revised their projects and then re-submitted them in the following week.	critical thinking and creative thinking (problem solving)
3	**Integrated sustainable manufacturing system design**	• The teacher played a brief 5-minute video clip explaining integrated sustainable manufacturing system design. • Students discussed, in groups of four, additional projects to include the design of an integrated sustainable manufacturing system, and then presented the revised projects. • Students listened to lectures from one of the members of expert panel E and the evaluations of the students' projects. • The students revised their projects and then re-submitted them in the following week.	creativity and collaboration
4	**Concept of the circular economy**	• Teacher introduced a brief 5-minute video clip explaining the circular economy concept. • Students brainstormed new circular economy projects in the groups of four before presenting the updated projects. • Student listened to lectures from one of the expert E and the evaluations of the students' projects. • The students revised their projects and then submitted them in the following week.	critical thinking and creativity
5	**A case study of the circular economy principles in a manufacturing system**	• The teacher played a brief 5-minute video clip about a case study of the circular economy's application in the manufacturing sector. • Students presented their revised projects after deliberating in groups of four on the benefits, drawbacks, and potential solutions of the proposals. • Student listened to lectures from one of the expert panel E and the evaluations of the students' projects. • The students revised their projects and then submitted them in the following week.	communication and creativity
6	**Integrating sustainable manufacturing systems and the circular economy**	Students worked on mini-projects related to sustainable manufacturing systems and the circular economy and presented the completed ones to a member of expert panel F for evaluation	critical thinking, communication and creativity skills

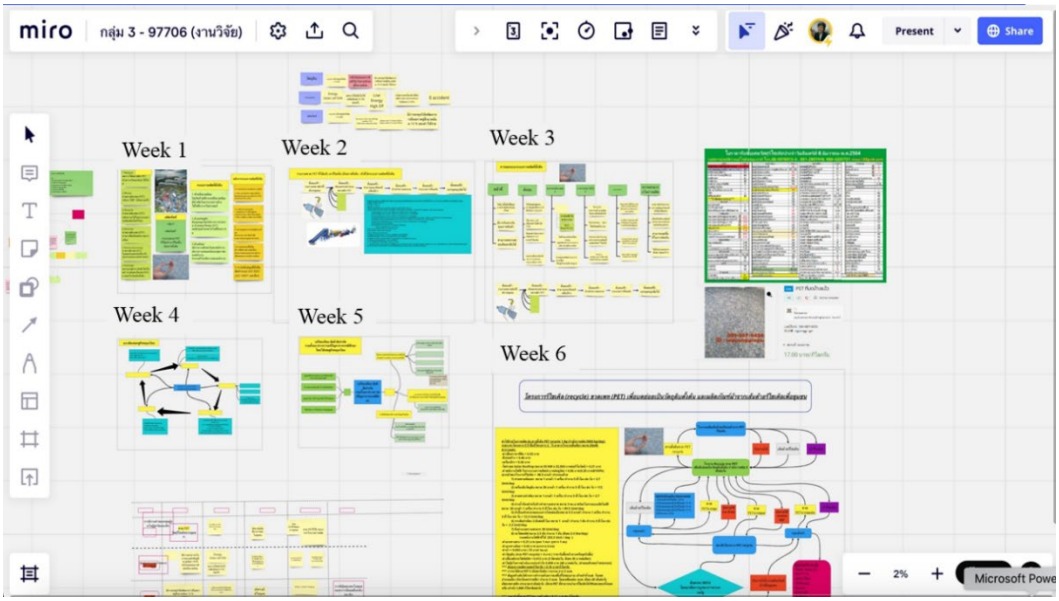

Figure 2: Examples of brainstorming activities through the Miro program

2.3.2 Evaluation of the model's effectiveness

To evaluate the model's effectiveness in terms of learning outcomes in the post-COVID-19 era, 3 steps of the ADDIE model were adopted and conducted: development (D), implementation (I), and evaluation (E).

2.3.2.1 Development

A competency-based learning model on Sustainable Manufacturing Systems and the Circular Economy (SMSCE) was used to create educational guidelines for students, and lecturers, including electronic learning (e-learning). Graduate students from the Department of Science and Technology who were enrolled in Course 97706: Engineering Management and Process Development in the first Semester of 2021 were used as a test group.

2.3.2.2 Implementation

The implementation process, instructional guidelines and several e-learning tools were introduced and used with the 12 students who enrolled on the course.

2.3.2.1 Evaluation

The evaluation process was split into the following three categories:

1) The results of learning both before and after were used to evaluate knowledge competency,

2) A seven-level semantic scale assessment about teaching and learning content was used with a competency-based learning model, attitudes were assessed, and

3) Expert panel E used a five-level rating scale to assess students' work each week through five weeks, and expert panel F used a seven-level semantic scale to evaluate the workpiece produced by each group of students. These experts also observed behaviours in each area by the four Cs. In addition, multivariate analysis of variance (MANOVA) was used to evaluate the factors that affect knowledge and abilities.

2.3.3 Investigation of student satisfaction

To investigate student satisfaction with the model for online learning in the post-COVID-19 era, student satisfaction with the competency-based learning model used by SMSCE in the teaching and learning process was evaluated with valid and reliable tools.

2.4 Analysis

Quantitative data was examined using t-test and MANOVA, whist qualitative data was evaluated using content analysis. The Human Research Ethics Committee of Yannasamvara Research Institute, Mahamakut Buddhist University, number 92.032/2560, accepted the design of this study prior to its implementation.

3. RESULTS

The research results were presented from model development, model trial with evaluation, and student satisfaction.

3.1 Development of a competency-based learning model for SMSCE teaching and learning

Before conducting the research, the proposed competency-based learning model for SMSCE teaching and learning underwent expert examination and human ethics certification. This PADICA model, as shown in Figure 3, consists of eight components and six steps.

The eight components are as follows: 1) learning content, 2) learners and learner roles, 3) the lecturers and the lecturers' functions, 4) competency-based learning procedures and activities, 5) subject matter experts, 6) learning interactions, 7) learning media, tools, and technologies, and 8) monitoring and evaluating competency-based learning.

The six steps utilized in the weekly major lessons were: 1) Planning (P), which involves systematic thinking and planning, problem analysis, and strategy analysis, 2) Analysis (A), which includes brainstorming ideas, and creating and proposing solutions, 3) Design (D), which is the process of developing and combining different strategies, 4) Improvement (I), which includes examining, enhancing, and correcting, 5) Confirmation (C), which involves brainstorming, analyzing, reviewing, and comparing, and 6) Application (A) includes the process of transferring, reflecting, improving, and extending.

Each of the six primary learning weeks was scheduled to move the process incrementally from planning to application. Each step was evaluated for the revision of projects or activities after suggestions were offered by an instructor or expert, in accordance with the procedure corresponding to the ADDIE Model theory (Seels, 1997) and the teaching and learning model ECEA-model of Luksanasakul et al. (2013).

The ECEA Model is divided into four steps: 1) Explore (E) students and lecturers comprehend the material together, and the lecturer describes the problems and objectives of the exercises and the instructional setting, 2) Construction knowledge (C) students do independent research using network technologies and

instructional media in the settings for which they were intended, 3) Exchange of experience (E) activities are carried out within the group as assigned, with the lecturer providing assistance and briefs when the work is completed, and 4) the Application (A) of knowledge, in which the students took the post-test.

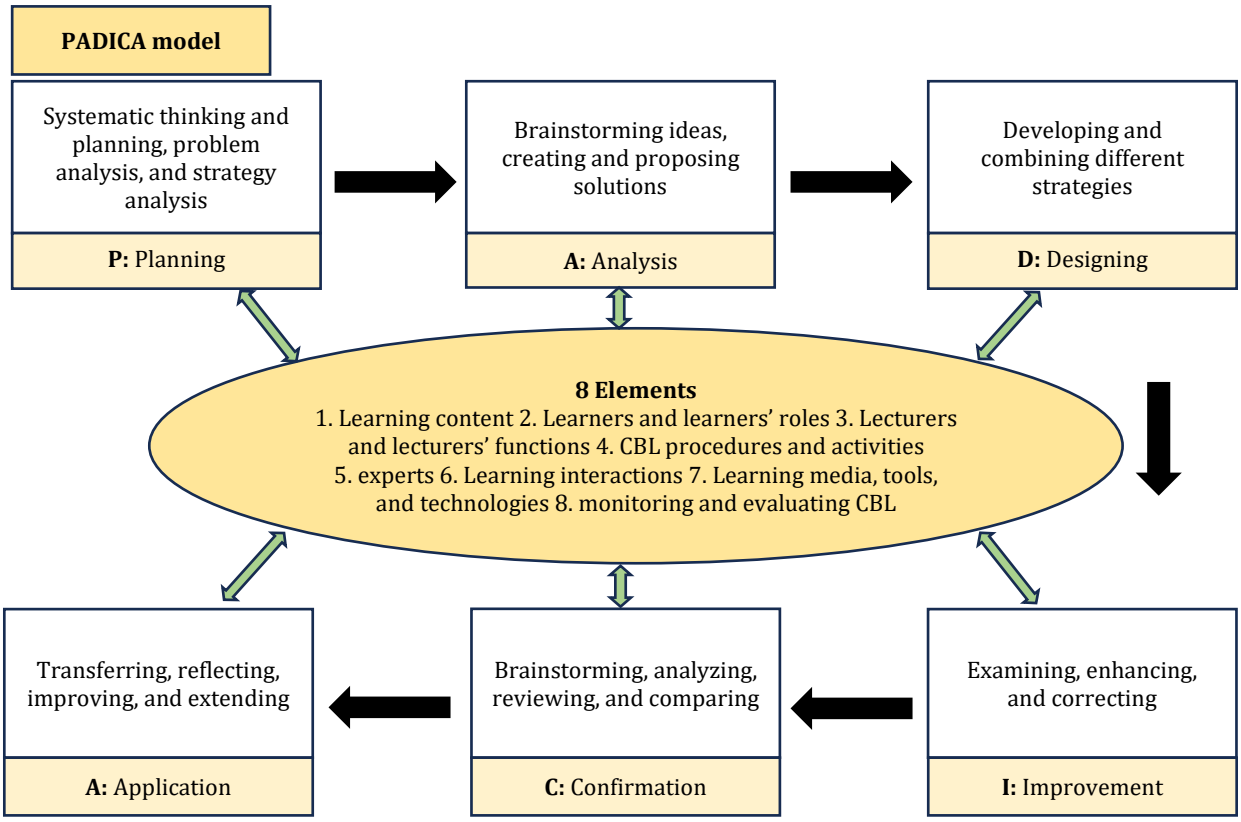

Figure 3: PADICA model for competency-based learning for SMSCE teaching and learning systems

3.2 Learning Outcomes of a competency-based learning model for distance education in the post-COVID-19 era

As shown in Table 2, it was found that the students' post-test scores were significantly higher than those from the pre-test, at the confidence level of 95 percent (p-value 0.003, less than 0.05).

Table 2: The mean scores of the pre- and post-test according to the competency-based learning model

Score	N	Mean	SD	df	t	Sig (1-tailed)
Pre-test	12	5.75	1.36	11	-3.752	0.003
Post-test	12	7.08	1.73			

Results of the evaluation of attitudes show that eleven out of twelve students, or 91.67 percent of those who were assessed for attitude, completed the questionnaire. Based on their best overall SMSCE performance (6.24 ± 0.10) and their highest-scoring learning style (6.45 ± 0.52) at the same level, the students' attitudes toward learning management were evaluated. The highest degree of learning styles supports the three abilities of critical thinking, collaborative skill, and creative thinking.

The learning styles that promoted communication abilities, let students apply their knowledge in the workplace, and which were found to be suitable for studying content all received the same score (6.36 ± 0.67), which was less than the earlier styles. When only the four skills, critical thinking, collaboration, communication, and creative thinking, were taken into account, it was discovered that students' attitudes toward the learning model that fosters these four skills, critical thinking, collaboration, and creative thinking were all on a par, as shown in Figure 4.

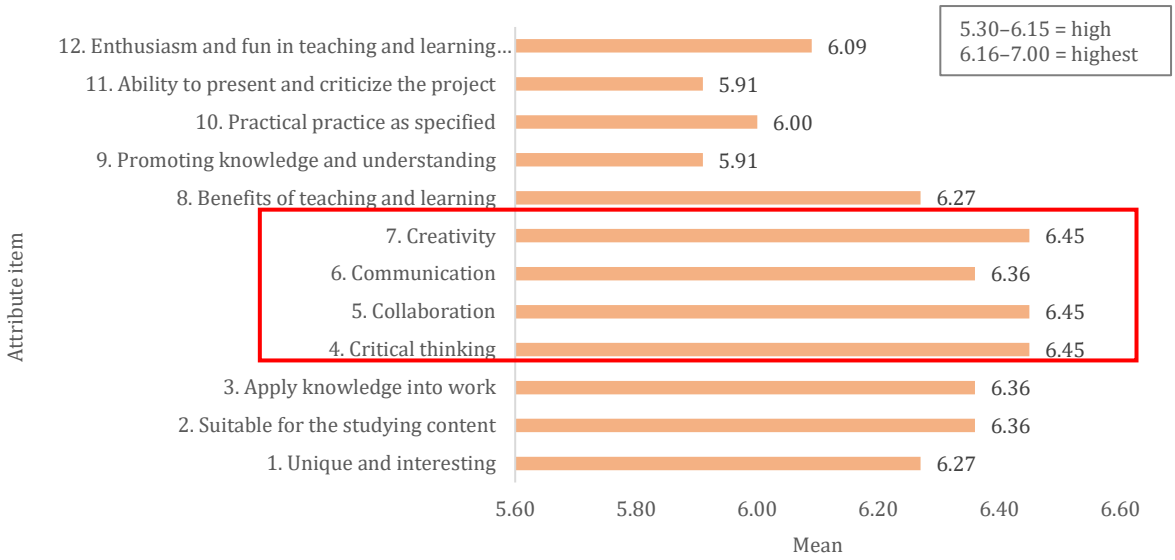

Figure 4: The findings of the study's attitude assessment of students enrolled in Course 97706

With respect to skill competency assessment results, the evaluation results are divided into two parts: those from the five-week skill competency evaluation, and those from the sixth-week project work evaluation.

3.2.1 The five-week skill competency evaluation

The evaluation results from expert panel E were returned only 3 out of 5 weeks, accounting for 60% of the responses. The three student groups (4 students per group), each ranked their ability to communicate as the highest, followed by collaboration and creativity. However, only Group 1 demonstrated above-average communication and collaboration. When considering the overall picture throughout the five weeks, the student's average performance in all four skills can be seen in Figure 5.

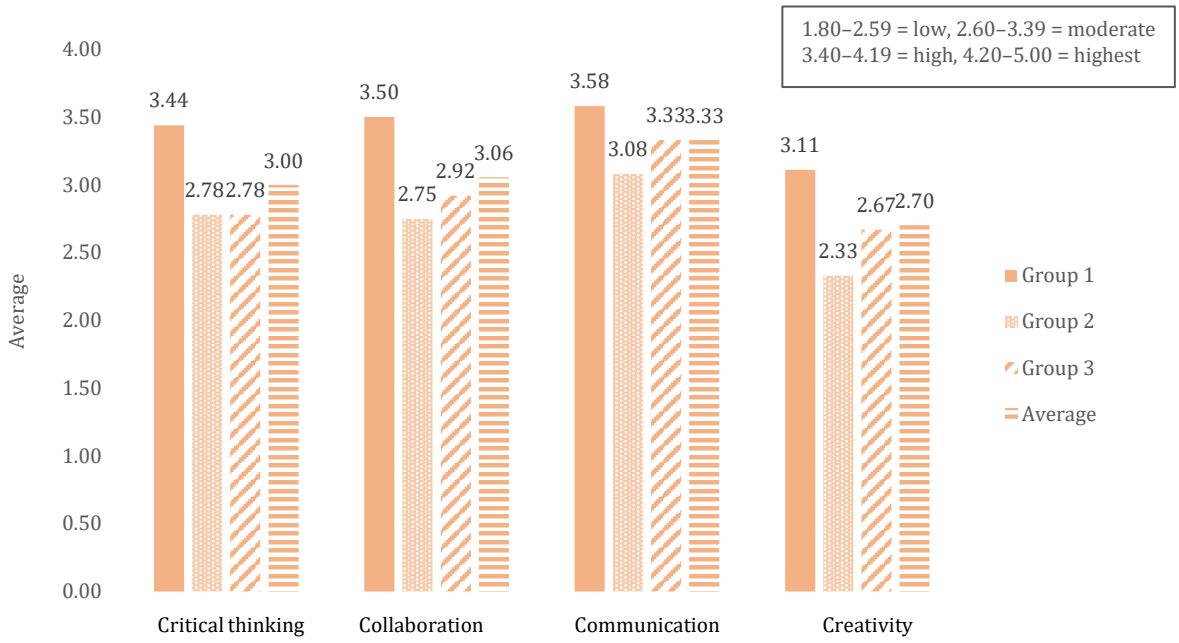

Figure 5: The average scores of the four skills competency assessments of the three student groups for the five weeks of the learning model

3.2.2 The sixth-week project work evaluation

The quality model results were evaluated by expert panel F in the sixth week, including the student-created group projects. The results of the skill competence evaluation are displayed in Figure 6. The students presented their projects incrementally over the course of five weeks, with the three topics being as follows:

"Production of Buddha statues from waste plastic polymers" (Group 1)

"Wastewater management in a plastic production factory" (Group 2)

"Production of raw materials from PET bottles for the production of woven fabrics" (Group 3)

Based on the competency assessment results from the presentation with seven levels of assessment from expert panel F, it was found that the overall average performance in all four skills of the three groups of students increased after completing 5 weeks of study, rising from a medium level to a very high level (4.78–5.21, with the criterion score ranging from 4.44–5.29), with critical thinking skills as the highest, followed by creative thinking, collaboration and communication skills. It was also found that Group 1 demonstrated creative competency skills at the highest level (6.22 with scoring criteria set: 6.16 and up), as presented in Figure 6.

The overall average performance of the three groups of students on all four skills improved after five weeks of study, from a medium level to a level of (4.78–5.21, with criteria scores ranging from 4.44–5.29), with critical thinking skills being the highest, followed by creativity skills. This can be seen in the competency assessment results in all four skills from the presentation with seven levels of assessment by three experts. Additionally, it was discovered that Group 1 had the highest level of creativity competency skills (6.22, with the scoring criterion set at 6.16 and above), as shown in Figure 6.

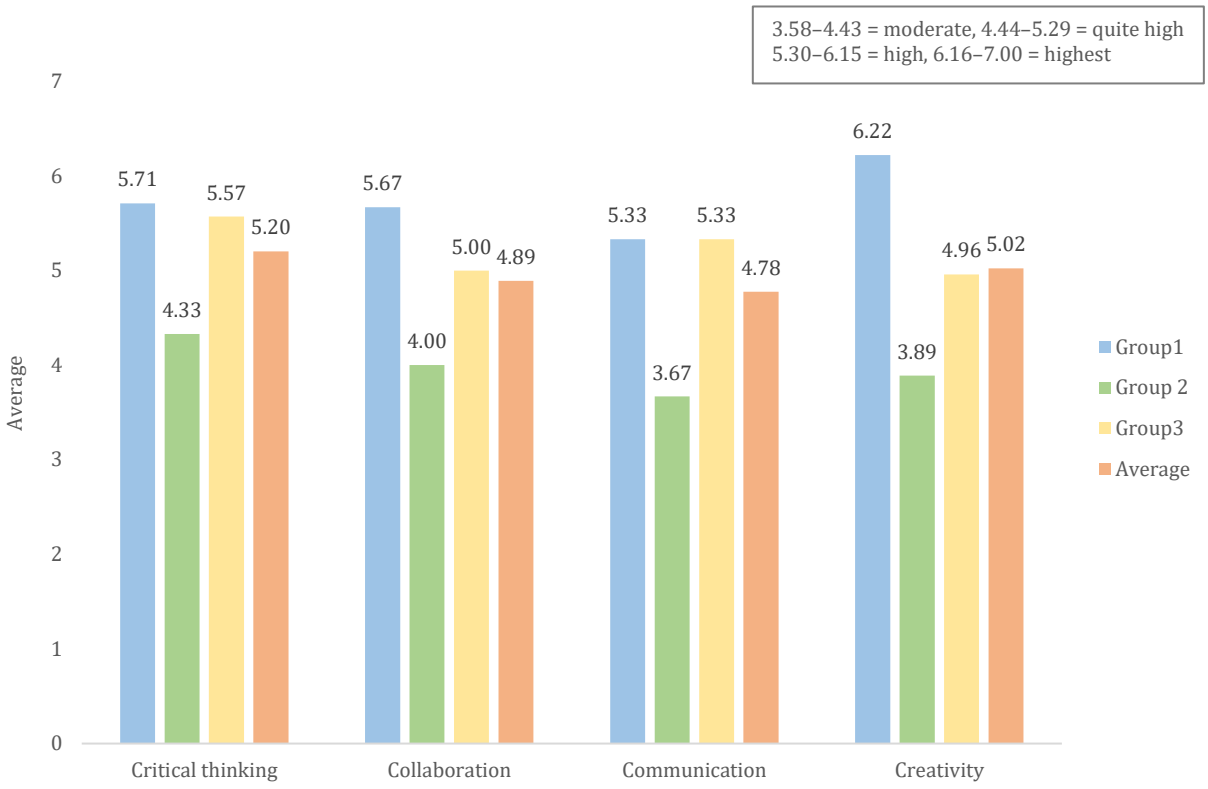

Figure 6: The average scores of the three student groups on the four skill competency assessments during the sixth week of project presentation

3.3 Results of students' satisfaction of a competency-based learning model for distance education in the post-COVID-19 era

In Course 97706, which had twelve students enrolled, eleven of them (91.6%) scored at the highest level of satisfaction (4.74 ± 0.16), with the highest level of satisfaction expressed in relation to the lecturers. The other areas teaching and learning management pattern, a system for assessing and evaluating teaching and learning, and instructional aids all received nearly the same average score, as seen in Figure 7.

According to student suggestions concerning the plastics business, it is important for them to learn more about SMSCE from lecturers and experts who are knowledgeable about the most recent scientific and technological discoveries and breakthroughs, such as new manufacturing methods. They are also aware of the significance of recycling waste to create value.

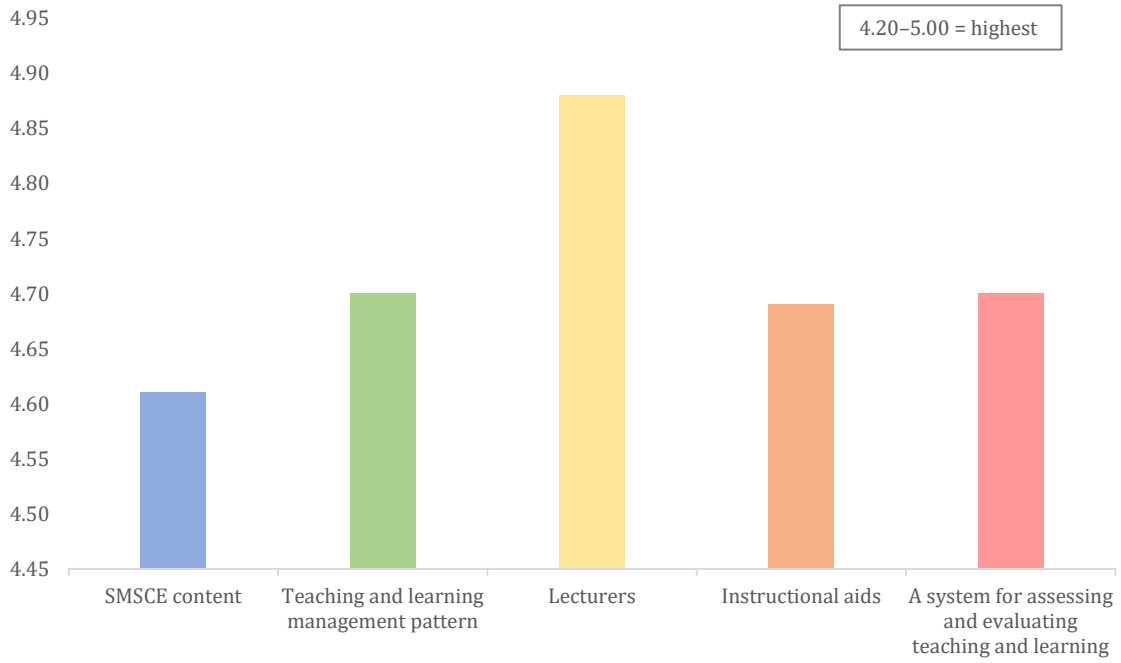

Figure 7: The average satisfaction assessment scores for teaching and learning management in Course 97706 of the SMSCE studies

3.4 Evaluation results of factors affecting knowledge and skills

Due to the identities of the respondents not being known the results for analyzing students' fundamentals relating to their attitudes are limited. The primary factor analysis of students was related only to knowledge and skill competencies, which are more than two dependent variables. It was done statistically using MANOVA (Multivariate Analysis of Variance).

The findings show that the fundamental variable of years of students' experience had a significant impact on knowledge and skill competency at the 0.05 level. Table 3 shows a positive correlation between years of students' experience and pre- and post-test results as well as the two skills of creativity and critical thinking.

Table 3: MANOVA results of factors affecting knowledge and skills

Source	Dependent variable	F	Sig.of F
Modified model	critical thinking	2.771	0.029
	collaboration	0.445	0.880
	communication	.824	0.591
	creativity	2.556	0.041
	pre-test	17.743	0.000
	post-test	75.931	0.000
Intercept	critical thinking	1563.919	0.000
	collaboration	184.125	0.000
	communication	227.936	0.000
	creativity	586.850	0.000
	pre-test	2560.154	0.000
	post-test	9824.641	0.000
Years of experience	critical thinking	2.771	0.029
	collaboration	0.445	0.880
	communication	0.824	0.591
	creativity	2.556	0.041
	pre-test	17.743	0.000
	post-test	75.931	0.000

4. DISCUSSION

The CBL model was discussed from the development stage, student performance evaluation during the model trial, and students' satisfaction.

4.1 The development of a competency-based learning model for distance learning on SMSCE in the post-COVID-19 era

4.1.1 The first draft of the model

The first draft of the model was based on focus group analysis results looking at appropriate activities, objectives, and media used in instruction. According to Sudsomboon's (2010) research, the SMSCE focus group should have invited the industry experts. Sudsomboon's was experimental research that focused on developing a curriculum framework in accordance with the competences related to automotive technology topics and content frameworks of performance analysis in automotive technology for the mechanical technology study program at King Mongkut's University of Technology Thonburi. Higher education academics from Thai institutions and commercial sector automobile training experts were included in the sample.

Based on the ideas generated during brainstorming, it was suggested that the students complete tasks or assignments, such as changing their attitudes from the ego-system, in which people attempt to maintain, enhance, and protect desired images of themselves in their own and others' eyes, without regard for the well-being of others to the ecosystem. By doing so, people can attempt to be constructive and supportive and not harm others when interacting with them.

Moreover, company policies should be developed and implemented that promote rational thought. In order to attain project practicality in the real world, systematic thinking is required along with actions such as switching from a linear economy to a circular economy.

The activities were divided into three sections: 1) Knowledge, which includes lecturer-provided e-learning lecture clips in the theoretical section, 2) Group projects or activities that let students apply knowledge and use necessary skills each week, and 3) Additional experience and knowledge from a relevant industry shared by a particular expert who delivered a lecture and provided comments on student projects.

Such methods were employed as part of the learning model that is consistent with the research of Laksanasakul et al. (2013). Their research established a teaching and learning model for the engineering of autotune control systems that took cognitivism and creative learning styles into account. The study approach started with content analysis, and the third phase involved developing an ECEA-Model teaching and learning model that relied on an exchange of knowledge between students and professionals.

4.1.2 Learning objectives

Learning objectives for planning and designing activities were created based on preliminary research results and used in designing a 6-week program of teaching and learning. Design results for each week were consistent with the lessons taught sequentially over the course of a 6-week program. The results of the PADICA model assisted students in learning and understanding more about sustainable development and the circular economy, including improving their competency skills. The overall average performance of all four skills improved after five weeks of study, from the medium level to much higher level. However, an inconsistent expert judgment during the first week's focus on objectives and performance-based learning outcomes led to results that were unusable (IOC value of 0.4). The suggestion was that each weekly activity should be adapted to behavior that can be measured empirically, such as project planning linked to performance-based learning outcomes. The designed activities should be adapted to expected competencies or skills, such as critical thinking, collaboration, and so on, which are in line with Orak & Al-Kreshehs' (2021) theory that learners can create knowledge by themselves and that experience stimulates the development of mental models known as schemas. When a learner uses knowledge and concepts to make something personally relevant to themselves, knowledge production is complete. Knowledge generation is a process that maintains a healthy intellectual balance between previous information and new environmental encounters.

4.2 Students' satisfaction with the competency-based learning model for distance education in the post-COVID-19 era

The result of the satisfaction assessment of the students using the competency-based learning model for distance education in the post-COVID-19 era as a whole showed satisfaction at the highest level (4.74 $\pm$ 0.16), being the highest followed by teaching and learning management patterns, measurement and evaluation of teaching and learning and instructional media at the high level and with similar averages.

Overall, evaluation of the post-COVID-19 competency-based learning model showed that satisfaction was at (4.74 + 0.16), with teacher satisfaction ranking highest. Teaching and learning management patterns,

instructional media, and techniques for monitoring and evaluating teaching and learning were all at a consistently high level with averages that were comparable.

According to the findings, lecturers had a greater impact on students' teaching and learning than the instructional media, teaching and learning style, assessment and evaluation, or other factors. As a result, it is clear that instruction must be delivered using a variety of media, and lecturers or other qualified individuals must effectively supervise activities. This will allow students to share their experience, which will improve their understanding of the material and help them to develop their competencies in all four skills (4C), in line with Kembara et al. (2019).

5. CONCLUSION

The PADICA model can be applied to other subjects that focus on development of the four Cs, for which there should be a list of particular experts who have sufficient time and skills needed to share their experience and give advice on the improvement of projects or student activities.

The PADICA model could be used for further research in industries that require enhancement of learning competencies in order to develop concrete projects that can be used in industry, including profound research skills, especially the creativity to generate innovative ideas in the industry. Moreover, there should also be a list of specific experts who have sufficient time, the skills needed to share their experience and who can offer guidance to developing projects or student activities.

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