Influence of Integrating Creative Thinking Teaching into Project-based Learning Courses to Engineering College Students

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1 INTRODUCTION

In the past, the engineering industries in Taiwan had been risen with the PC development. Through the parallel division mode of global factory, Taiwan technology companies provides the hardware solutions of original equipment manufacturer (OEM) and original design manufacturer (ODM) to the world computer manufacturers. This makes the output value of Taiwan IT industry leaped to the top three in the world. However, with the rise of internet-related activities, the focus of IT industries are no longer on the hardware manufacturing technologies, resulting in the loss of international competitiveness in Taiwan IT industry. Instead of labor intensity, creative internet services become more popular and pervasive that promote Taiwan government began the revolution of engineering education. Regarding of innovative and creativity education, most of the approaches in Taiwan focus on how to motivate children imagination, including goals, attitudes, motivation and thinking mode. From

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the standpoint of personality traits, the teachers and their teaching model play a key role to affect the development of students' creativity directly in creative teaching.

In recent years, the colleges have introduced the curriculum about imagination and creative thinking, but most courses still be included in the relevant departments or the teaching centers to foster students' innovative thinking. But there are few researches or approaches that combine with engineering and educational backgrounds to provoke students to solve complex real-world problems. Therefore, how to design an interdisciplinary approach integrated technical expertise and creative thinking to college courses is an interesting challenge. There are two following issues that are closely related to the construction of creative teaching approaches:

Transductive Thinking: With the advancement of engineering technologies, IT products change not only the behavior of people's lives but also the mode of communication between people. This situation makes people gradually only interact with their phones but ignore the real human contact. When consumers choose IT products, they will consider the perceived usefulness and the perceived ease of use at the same time. Generally, most of the polytechnic students have excellent mathematical and logical thinking ability, but often are limited by the traditional logical thinking modes. It leads the students subconsciously ignore the original purpose of designing IT products to chase the improvement of functional performance. In other words, the user experience and product design innovation has never been considered. Hence how to arouse students their imagination and people-oriented concept in the engineering courses is a big challenge.

Effectiveness Evaluation of Learning Creativity: For learning the professional knowledge, when students design their IT prototypes with creative thinking, questionnaire and evaluation are adopted to determine whether the student can explain the main materials and focus of the course, or enhance their ability of organizing and analyzing. However, how to evaluate the students' promotion of imagination and determine whether they escape the old thinking patterns from the long-term learning behavior data is one of the main issues to be overcome in this study.

2 CREATIVE THINKING TEACHING INTO PROJECT-BASED LEARNING COURSES

Regarding of Taiwan education model, most of the teachers instruct their students by top-down approaches. In other words, when one teacher is giving lessons, he must take care of more than one students. Students are limited to absorb knowledge from the teaching materials in class, and this teaching approach has killed most of the students' creative thinking and imagination, making the most of the graduated students apply their knowledge learned from colleges directly to the workplace. With the era of progress and development, textbook knowledge is insufficient to deal with the problems in real life, and so that Taiwan government abandon traditional teaching methods for education revolution. Through the learning of across domain knowledge, it leads students think from various sides. Students are able to select the real world problems they are interested, then try to discover the solutions by group discussion, problem analysis, solution construction, and the result presentation. In the course of learning, teachers wouldn't longer illustrate lectures, but play a consultative role to lead students to think for the problem by themselves.

In this study, ADDIE teaching policy (as shown in Fig. 1) that contains Analysis, Design, Develop, Implement and Evaluate phases were introduced. Through ADDIE approach, teachers are able to take dynamic teaching strategies to arouse students' creative thinking. And creative thinking models and project based learning theory are integrated into ADDIE teaching strategies at the same time. In Analysis phase, student's basic personality, curriculum materials, teaching strategies, and engineering teaching environment will be analysed. After completing the analysis of the previous conditions, during Design phase, teachers would institute the syllabus, curriculum planning and teaching strategies of innovative thinking. Students are trained to learn professional abilities within information collection, data analysis, group discussions, result verification and project presentation in order to motivate them interest by illustrate real world problems. In Develop phase, the planned teaching strategies in Design phase will be implemented. When students participate in project-based learning courses, they can be evoked imagination by various approaches of cultivating innovative thinking integrated into teaching and feedback activities, such as analogy, reverse thinking, interdisciplinary thinking, etc.. In Implement phase, teachers raise the problems that occur in real life, then try to motive students to seek the novel solutions to solve those problems via the integration of IT technologies and innovative thinking approaches. In order to enable students to have more imagination space for agitating his solutions with other mates enduringly, teachers or assistants shall suitably provide appropriate clues. On the one hand teachers can modify the course materials or teaching policy based on students' adaptation status, and on the other, the state changes of students' imagination in the course period are collected for Evaluate phase. After completing the course, the engineering experts and creative teaching educators will be invited in Evaluate phase to evaluate the course materials and the effectiveness of learning creativity according to the characteristics of creativity, such as Originality, Elaboration, Fluency, Flexibility, etc.. The engineering student are expected to construct novel IT prototypes in the project-based learning courses integrated creative thinking teaching.

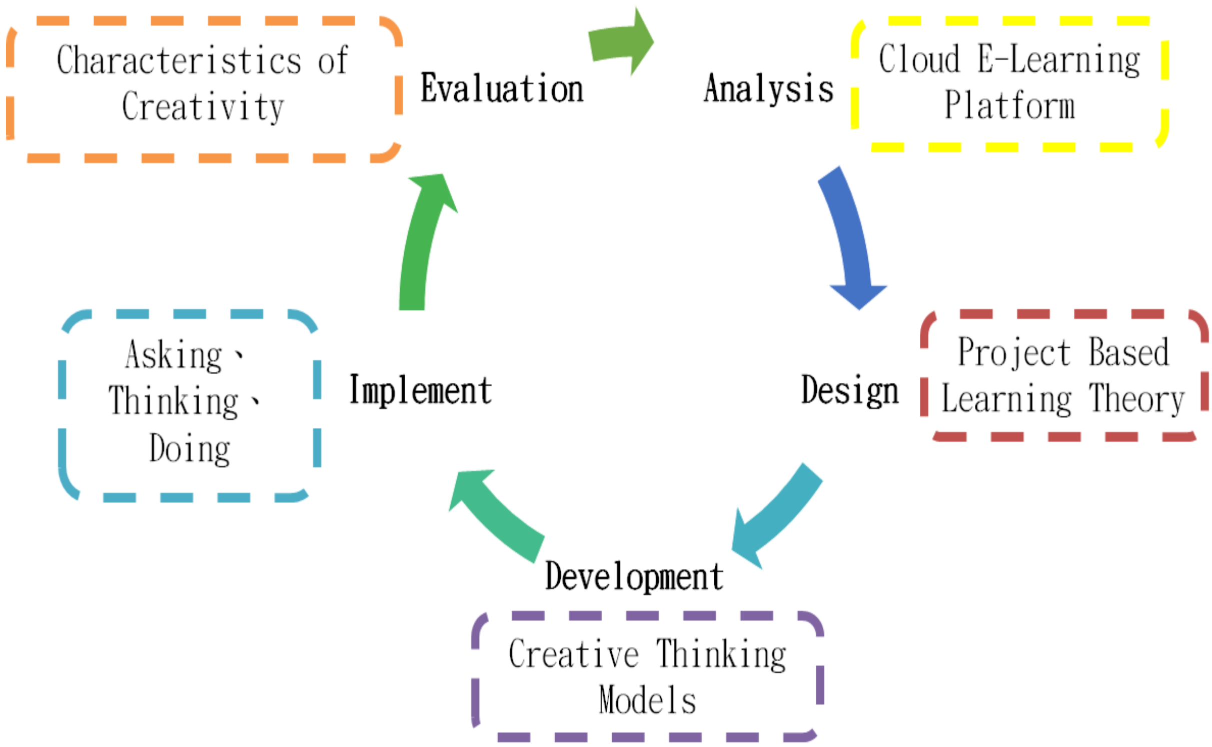

Fig. 1. ADDIE Teaching Policy Integrated Creative Thinking Models and Project Based Learning Theory

3 METHODOLOGY

3.1 Participants

At CCU College of Engineering, there were 23 students participated a project-based learning course. Every student enrolled in the Internet of Thing (IoT) course was required to design one IoT project by team work with two or three members. In other words, a total of 10 individual interesting projects were generated. The duration of the study was an 18-week period. Students were required to learn sensor network, circuit design and software programming on the project-based learning system.

To learn creative thinking, the students were asked to procure in the following activities, i.e. watching the video materials about imagination and creative thinking, giving hand-written reflections about the material, discussions in class, etc. Then they were asked to revise their own group's project by taking creative thinking approaches.

3.2 Procedure of Experiment

Week 1 (preparation): The teacher began the course with a brief overview of the IoT technologies and the students were tested as pre-test data of imagination status.

Week 2-7 (professional knowledge learning): The students learned the IoT knowledge in the class, and then the teacher assigned one implementation lesson each week to make sure the students fully understand what they learned. After the lesson status feedback was received, the teacher was then allowed to redesign teaching materials.

Week 8 (real world problems illustration): The teacher illustrated real world problems to help the students having clearer problem contour and motivate their learning interest.

Week 9-10 (1st round project design): Each group was asked to design a IoT project to solve real world problems.

Week 11 (creative thinking): The creative thinking models were introduced to the students in this week.

Week 12-13 (2nd round project design): Each group was asked to adopt creative thinking modes to redesign a IoT project. And the two rounds project designs were recorded.

Week 14-17 (project development and implementation): Students had developed and implemented their IoT project in 4 weeks.

Week 18 (final project presentation): Each group presented the design concept and final project. And the engineering experts and creative teaching educators were invited to evaluate the effectiveness of learning creativity among 1st round project design, 2nd round design and final project.

Table 1 showed the procedure of this experiment.

Table 1. Procedure of Experiment

Week	Subject	Task
Week 1	Teacher	1. Introduce a brief overview of the IoT technologies. 2. Explain course outline and scoring criteria.
	Students	1. Get basic understandings about the IoT technologies. 2. To be tested as pre-test data of imagination status.
Week 2-7	Teacher	1. Teach the IoT knowledge.

		2. Design the course materials.
	Students	1. Learn the IoT knowledge in the class.
		2. Implement the course lessons
Week 8	Teacher	1. Illustrated real world problems.
Week 9-10	Teacher	1. Monitor students' project creation.
	Students	1. Design a IoT project with team members.
		2. Have preliminary and final versions of projects submitted.
Week 11	Teacher	1. Introduce the creative thinking models.
		2. Give a reminder for late work.
Week 12-13	Teacher	See week 9-10.
	Students	1. Revise and upload projects.
Week 14-17	Students	1. Develop and implement their IoT project.
Week 18	Teacher	1. Gather and analyze the design, figure out the students' final score.
	Students	1. Oral design presentation and final project demo in the classroom.

4 RESULTS AND DISCCUSSION

Along with experiment data related to the effect of IoT projects on students' technological creativity, ANCOVA approach was adopted to analyze the effect among different groups. And the students' original creativity was controlled after verifying the homogeneity of variance assumptions. The improvements of students' creativity thinking and imagination during the course were the main scope in this study, especially from the standpoint of convergent and divergent thinking.

The experiment data was analysed for reviewing the purpose of the study, namely to identify the creativity characteristics of student creativity during the IoT course. The data was analysed by 6 categories of creativity characteristics. The consistency checks was adopted to assess the trustworthiness of the qualitative data analysis and the quantitative evaluation of creativity showed that the alpha coefficient for inter-rater reliability was 0.98. In the experiment results, post-test means and standard deviations for each group are presented in Table 1 and ANCOVA results are presented in Table 2. Two phenomena had arisen to be discussed.

(1) ANCOVA revealed significant differences in product creativity ($F = 5.97$, $p < 0.05$), style and function, as shown in Table 2. The experiment results also pointed out that the scores of style ($F = 26.38$, $p < 0.01$) and function ($F = 15.06$, $p < 0.01$) were significantly highly correlated. According to Tukey's post hoc analysis, the mean scores for the product creativity of the traditional (1st round design) were evidently lower than those for the creative thinking (2nd round design). The same results were found in the scores of style and function.

(2) ANCOVA showed minor differences between the two rounds in their scores on divergent thinking, creativity tendencies and elaboration. These results, in general, showed that the feedback from the experts and educators was useful in helping students to better develop their engineering projects.

Table 1. Scores on creativity and project creativity

	Creative Thinking (2nd Round Design) (n=23)	Traditional (1st Round Design) (n=23)
Divergent thinking		
M	32.14	36.28
SD	5.25	6.40
Creativity tendency		
M	28.21	29.81
SD	4.63	5.24
Product creativity		
M	21.33	16.12

SD	9.30	8.18
Elaboration		
M	11.63	10.13
SD	3.62	3.31
Style		
M	25.23	17.36
SD	3.79	4.37
Function		
M	14.29	9.65
SD	2.95	3.23

Table 2. ANCOVA of the scores on creativity

Item	Source	*SS*	*DF*	*MS*	*F*	*p*	Post-hoc Comparison
Divergent thinking	Pre-test	489.53	1	489.53	23.83	0.000	
	Between groups	38.12	1	38.12	1.86	0.18	
	Within group error	2197.72	22	20.54			
Creativity tendency	Pre-test	192.32	1	192.32	4.94	0.028	
	Between groups	23.50	1	23.50	0.60	0.44	
	Within group error	4164.51	22	38.92			
Product creativity	Pre-test	82.54	1	82.54	5.88	0.017	
	Between groups	83.80	1	83.80	5.97	0.016*	G1>G2
	Within group error	1501.20	22	14.03			
Elaboration	Pre-test	7.71	1	7.71	2.52	0.115	
	Between groups	2.98	1	2.98	0.98	0.325	
	Within group error	327.01	22	3.05			
Style	Pre-test	5.69	1	5.70	7.37	0.01	
	Between groups	20.42	1	20.42	26.38	0.000**	G1>G2
	Within group error	82.87	22	0.77			
Function	Pre-test	9.39	1	9.39	9.49	0.003	
	Between groups	14.91	1	14.91	15.06	0.000**	G1>G2
	Within group error	105.93	22	0.99			

$*p < 0.05$; $**p < 0.01$

5 CONCLUSION

This study explored the influence of integrating creative thinking teaching models into project-based learning courses to engineering college students, and to analyze the effect of various creativity characteristics to students. There were 23 students participated a project-based learning course. Every student enrolled in the IoT course was required to design one IoT project by team work with two or three members. The duration of the study was an 18-week period. Students were required to learn sensor network, circuit design and software programming on the project-based learning system. In order to push the students in the course can inspire their imagination and creativity effectively, the five stages of project-based teaching period is adopted: 1) Planning of the stages, phases and milestones of course; 2) Design of the teaching activities and creativity evaluation; 3) Development of the teaching activities and creativity evaluation; 4) Implementation of the project-based learning course; 5) Presentation of the projects consequences and assessment the creativity efficiency. ANCOVA was conducted and the results shows the students' imagination significantly was improved by being involved with the creativity learning activities. This study was geared towards creative thinking for students to enhance their imagination in college engineering education via creative thinking models and project based learning theory. After the students learned the creativity thinking models in the class, they could give group discussions to revise their original project design. This study explored the relationship between the creativity characteristics and the final project presentation. As teachers provided more teaching material about creativity thinking models, students may not have better performance to creativity thinking, even though they have been designed their projects according to the creative thinking model. It was found the engineering college students are more rational and with logical thinking since the creativity characteristics, Style and Function, are more intuitive creativity characteristics to the engineering college students in this experiment. It was also found that if the students were able to more easily understand the concept of creativity, they could design a surprising project sketch via the creativity thinking models.

According to our findings, some creativity characteristics and students' final project designs were significant and consistent, implying that the personality traits and logical thinking were adequate to reflect creativity achievements. Therefore, the creative thinking teaching Integrated into project-based learning courses could be regarded as a valid method that will contribute to foster creative engineers in future product development environments.

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