Creative Thinking Instructional Strategy in the Project Curriculum for Information Engineering Students

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INTRODUCTION

The Industry 4.0 era, or the Fourth Industrial Revolution, has arrived, which marks the beginning of intelligent manufacturing times, facilitating the convergence of physical and digital worlds and giving rise to the Smart Factory [1]. We have come to an age when formerly separate manufacturing processes link together, when data-controlled equipment and automated systems improve precision and boost quality and capacity. As technologies and ideas like the Internet of Things (IoT), big data, “the cloud”, and Artificial Intelligence (AI) become the center of attention, it is required, in addition to technical knowledge, for engineers to have the ability to imagine and to create [2]. They must master fields like mechanics, computer science, and information engineering, but more importantly than ever, they need a touch of imagination and creativity to catch up with the fast-changing knowledge-based era, or even, to be ahead of it. Education, too, needs to change as fast as technology. It is now crucial to guide students to think creative for them to survive and thrive in the new age. However, through an examination of the curriculum designs in Taiwan’s current education system, we believe that a more creativity-focused design is in need. Such design is even more critical for vocational high school students, because if they learn to think creative in an early age, a better adaptation to technology universities and to their careers can be expected.

In Taiwan, a Project Practice course is a required course for every vocational school. Project Practice applies a project curriculum that applies the Problem-Based Learning (PBL) pedagogy, which is student-centered and requires active learning. However, most Project Practice courses in Taiwan use traditional teaching method that does not focus on creative thinking. Therefore, we propose a project curriculum that combines a creative-thinking instructional strategy into the course. In our design, as students work on an assigned or optional project individually or by teamwork, they will need to use imagination and creativity to come up with ideas and solutions. Since current curriculum designs lack such trainings, students may feel frustrated with struggles for ideas or fails of a practical solution. Thus, we apply a convergent creative-thinking instructional strategy to cultivate each student’s unique performance and to help generate imagination and creativity.

We worked with vocational high school instructors to conduct this exploratory research. Our purpose is to examine the effect of such curriculum design, and to make suggestions for any possible revision to bring about a more complete design that can be applied on a more general basis for vocational high schools and also technology universities.

1 BACKGROUND

Creative-thinking instruction is a teaching strategy for increasing student creativity and has been proven by many previous studies to be effective [3]. Creative-thinking instructional strategy aims to bring out students' creativity through customized activities and dynamic learning strategies. Generally speaking, two approaches for creative-thinking instructions can be conducted. One is to design an independent course for creativity training with teaching materials base on creative thinking. The other is to implant creative-thinking into preexistent course content. The latter method is usually considered more practical for regular education and thus carried out more often.

When implanting creative thinking instruction into preexistent course content, project-based learning is practical and efficient for cultivating creativity [4, 5]. It is crucial to offer a supportive learning environment when applying creative-thinking instructions [6]. Csikszentmihalyi [7] and Sternberg [8] both point out learning environment is a key factor for individuals to develop creativity. Peterson [9] argues that an interesting and simulative learning environment can arouse curiosity and encourage students to identify problems and increase communication. Therefore, we believe implanting a creative-thinking instructional strategy into our curriculum design would be suitable for generating insightful results.

2 RESEARCH PURPOSE AND QUESTIONS

This study integrated a creative-thinking instructional strategy into a project curriculum. The following research questions have been formulated: What is the effect of a creative-thinking instruction implanted project curriculum on vocational high school students? Can such curriculum enhance students' creative thinking abilities?

3 METHODS

3.1 Instructional contexts: Creative-thinking instruction and project curriculum at vocational high schools

The purpose of a project curriculum in vocational education is to cultivate students' creative ability [4]. Project curriculum is a project-based learning environment in which students can acquire procedural knowledge and apply such knowledge to solve practical problems [10].

The creative-thinking instructional project was designed by the authors together with an instructor who teaches a project course at a vocational high school. A two-hour weekly class that lasted nine weeks, which was in total a course of eighteen hours, was proposed. During the project design process, we consulted an expert in the creative-thinking field and two senior instructors who have had teaching experience in the field of Information Engineering. Our final draft was approved of by these experts.

Our goal is to guide students to come up with a practical plan for their projects; therefore, the major instructional strategy in our design is brainstorming, while Attribute Listing and the 6W divergent thinking technique are also included, to help students acquire abilities to (1) think creative, (2) master creative-thinking strategies, (3) assess practicality, and (4) innovate. We hope students can at least realize the importance of creative thinking and be actively responsible for a creative climate and participate in a self-realizing learning environment.

3.2 Participants

Our participants were 85 senior majors in information engineering at a vocational high school in New Taipei city, Taiwan. This school is located in an industrial area where the socioeconomic level is medium.

3.3 Experimental Procedures

We applied a nonequivalent pretest-posttest Quasi-Experimental Design, which separates a total 85 students into an experiment group of 41 and a control group of 44, with the assessment tools of New Creativity Test for Use with Students in Taiwan, developed by Dr. Ching-Chi Wu, and the Torrance Test of Creative Thinking (TTCT) to measure the differences in creative-thinking ability. Our procedures went as following:

Procedure 1: Pretests. To have baseline control for the outcome, a pre-test was carried out for both groups a week before the experiment. All 85 students finished the creative-thinking assessment test, and 85 valid questionnaires were received.

Procedure 2: Experiment. Then we carried out our project curriculum in the experiment group, while the control group continued to receive traditional teaching methods.

Procedure 3: Posttests. After the nine-week curriculum ended, a posttest was carried out in both groups on the same day. All 85 students finished the creative-thinking assessment test, and 85 valid questionnaires were received. Test scores were then evaluated by researchers.

4 RESULTS OF CREATIVE-THINKING ABILITY

We conducted One-way ANCOVA to examine the four aspects of students' creative-thinking ability: (1) fluency, (2) flexibility, (3) originality, (4) elaboration, and overall creativity to see if there is any difference between the experiment group and the control group. Results are presented in Table 1, which suggests that creative-thinking abilities in the experiment group improved in all aspects: fluency ($F(2, 81)=3.35$, $p<.05$), flexibility ($F(2, 81)=17.03$, $p<.05$), originality ($F(2, 81)=4.16$, $p<.05$), elaboration ($F(2, 81)=3.54$, $p<.05$), and over all creativity ($F(2, 81)=3.66$, $p<.05$).

Table 1. Results of creative thinking ability

creativity	Groups	Average Score	SS	Df	MS	F	Sig.	Effect size
Fluency	Experiment group	50.99	318.66	2	159.33	3.352	0.04	0.07
	Control group	49.82	3849.66	81	47.53			
Flexibility	Experiment group	50.82	2926.20	2	1463.10	17.03	0.00	0.30
	Control group	49.59	6960.47	81	85.93			
Originality	Experiment group	51.25	442.25	2	221.13	4.16	0.02	0.09
	Control group	49.57	4607.83	81	53.18			
Elaboration	Experiment group	50.57	424.89	2	212.45	3.54	0.03	0.08
	Control group	50.42	4857.99	81	59.98			
Overall creativity	Experiment group	203.86	5453.33	2	2726.67	3.66	0.03	0.08
	Control group	199.02	60314.61	81	744.63			

5 CONCLUSIONS AND FUTURE SUGGESTIONS

Based on our research results, we conclude that students can indeed benefit from a project curriculum that applies a creative-thinking instructional strategy. After learning in the nine-week project course, students in the experiment group scored higher in every aspect on the creative-thinking ability test than those in the control group. Thus, we conclude with great confidence that brainstorming and the 6W technique (Attribute Listing) are effective ways for creative thinking in engineering education. Our results confirm earlier research that students' creative -thinking abilities can be enhanced through instruction [8, 11].

With these findings and our belief in that creative thinking is important for students of all fields, we strongly suggest that future studies examine the effect of the application of such project curriculum design on students of other majors and/or of different grade levels.

6 SUMMARY AND ACKNOWLEDGEMENTS

As we enter the Industry 4.0 era, we must emphasize the need to reinforce the new generation’s ability to imagine and to create through education. For information engineering students, creativity is crucial because they have to master and integrate several different fields of knowledge, and because their potential future career requires them to be ahead of the fast-changing knowledge-based era. Thus, for educators, it has become more important than ever to apply new teaching methods that can inspire students to think creative and to adapt themselves for the new era.

Bearing this in mind, we designed a nine-week project curriculum that aims to generate creative thinking for information engineering students. To test the effect of our design, a nonequivalent pretest-posttest quasi-experimental design was applied, which separated a total 85 students into an experiment group of 41 and a control group of 44, with assessment tools of New Creativity Test for Use with Students in

Taiwan, developed by Dr. Ching-Chi Wu, and the Torrance Test of Creative Thinking (TTCT) to measure the differences in creative-thinking ability.

Research results indicate that the curriculum design has positive effects in all four aspects: fluency, flexibility, originality, and elaboration. We suggest future studies make possible revision to bring about designs that can be applied on a more general basis for not only vocational high schools but also technology universities, or even for other majors and/or of different grade levels.

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