Improving Project Making in Engineering Education by Innovative Designing Teaching Methods

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Abstract: Project making is a required course for both senior university and college students who major in Engineering. However, researches have proved that the traditional teaching methods have limited effect on inspiring students' innovative talents. In this study, therefore, in order to upgrade students' project making abilities, first of all, researchers would focus on investigating, analyzing and drawing out the factors that influence Engineering students to apply innovation when they are conducting a project. According to these factors, researchers, then, design the teaching contents, selects Engineering students as examinees in order to carry out the experiment of the newly designed teaching methodologies. Researchers further on would compare the before test and after test to not only clarify the results but also draw out a consequence which shows the spheres that require further strengthening in the teaching methodologies and teaching guidance.

Keywords: engineering, innovation, project making, teaching methodology

1. Introduction

Project making is a required course for both senior university and college students who major in Engineering. In the conventional teaching methodologies, students are required to design and produce a product which both the appearance and functions may similar to the ordinary commodities. Students, with the acquisition of the experience of imitation, can only develop the techniques strengthening on observation and manufacturing. Since now Taiwan is a developed country, the labour costs are getting higher. While most manufacturers turn to oursource from Mainland China and South-East Asia countries to get lower labour rates. Jobs that contribute to the new economy will require workers who are prepared to absorb new ideas, to perceive patterns, and to solve unconventional problems. However, traditional approaches to creativity training has been much more circumscribed in scope and have often conceptualized critical thinking, decision making, and metacognition as being outside the realm of creative thinking[1]. Because knowledge in the future will have a short half-life, future oriented educators advocate the shift from a view of learning as a passive acquisition of discipline-based subject matter to one of process –the active seeking of knowledge by each student. The engineering educators, the subject matter of this study, should transfer their focus on nurturing and developing students' creativity.

The programme of developing students' creative thinking has carried out in the elementary and the junior high schools in Taiwan. On the other hand, the universities, instead of developing students' abilities on manufacturing, has altered the objective of project making programme to foster students' creativity.

The government, to support the programme, has carried out some activities, such as the contest of robot designing and manufacturing and the contest of project making in higher education. While this one aspect has gained broad attentions, we have acknowledged the importance of these works, particularly those involved in how to improve the teaching methodologies in order to foster students' creativity. Our objective yet in this special issue on creativity aims to contribute to creativity development by using an empirical research approach to examine how students generate creativity under teachers' instruction and stimulation.

2. Theoretical Bases of Creativity

Creativity is a multidimensional concept, open to different views and positions. One such view is that the potential for creative thinking exists to a greater or lesser degree in everyone[2]. This concept underlies the view

of creativity as a normative process available to everyone. It is the most precious asset that humankind possesses. Creative thinking is a complex cognitive activity. The conceptions of creativity are so diverse and extensive that a definition of creativity must include related cognitive activities such as decision making, critical thinking, and metacognition[1]. Guilford (1988)[3] suggested the components of creativity include sensitivity to problem, fluency, flexibility, novelty synthesizing ability, reorganization or redefinition, complexity and evaluation. Williams(1972)[4] further added the measurements are consistent with cognition behaviour and situation behaviour. A creative individual can generate the ability to investigate the situation around and then establish the environment that can lead to originate inspirations and drives of creativity. Ristow (1988)[5] believed that there is consensus on creativity as a person's capacity to produce ideas, inventions, artistic objects, insights, restructurings, and products which are evaluated by experts as being of high scientific, aesthetic, social, or technological value.

3. Project making, curriculum design and creativity

Most curriculums designed for college students are focused on knowledge and techniques learning. Fostering creative thinking is relatively less emphasized. However, a well-designed project making can facilitate creative thinking. Creativity is often defined as a parallel construct to intelligence, but it differs from intelligence in that it is not restricted to cognitive or intellectual functioning or behaviour. The applications of creativity are based on a knowledge structure that constructed by the core knowledge structure and the relevant knowledge structures. To foster creativity in students by carrying out a project making, therefore, the core knowledge structure has to be established prior to conduct a project. Since the implication of defining problems, identifying relevant knowledge structures, combining and reorganizing knowledge structures to generate a new understanding and ideas result in the solid foundation of core knowledge structure, teachers has to provide efficient core knowledge in order to entice students understanding and interests and then advance to extant the knowledge structure.

Torrance (1972) [6]defined creativity as a set of abilities, skills, motivations, and states that are inextricably linked to dealing with problems. According to Mayer (1992)[7], creative teaching refers to instructional techniques that are intended to help students learn new material in ways that will enable them to transfer what they have learned to new problems. Research on instructional methods suggests the following four conditions for creative teaching: the to-be-taught material must be potentially meaningful; the student must not naturally engage in active learning processes; the instructional method must be intended to foster active learning processes in the learner; and evaluations of learning outcomes must measure students' creativity. The programme of creativity implemented in this study emphasized on providing students a safe and free atmosphere that can facilitate students to explore and develop creativity in their own field. Amabile (1996) [8]conceptualizes the external input as an incoming stimulus and sees the initial impetus as coming from within the individual. Rhodes(1961)[9]and Hayes (1989) [10]proposed that creativity consists of a process, a product, a person, and a situation. Some theorists refer to the latter as press or environmental press. According to Grant (1988)[11], "Students learn more when opportunities for learning increase, when they are actively engaged in activities, and when they are relatively successful in solving the problems presented." The environment in the campus has a great impact on fostering creativity in students. Creative processing then involves memory and environment search, response generation, and response evaluation. Influencing the whole creative process are tasks motivation, domain-relevant skills, and creativity-relevant or processing skills.

Guilford (1967) assigned a role of major importance to evaluation ability in his models of relative thinking and problem solving. He suggested that evaluative functioning operates throughout all stages of a creative or problem-solving behavioral sequence. Torrance (1972) further suggested that in selecting creativity tests one should be guided by relevance of a given test to creativity theory, relevance to adult creative behavior, extent of sampling of different aspects of creative thinking, and openness to individual styles and background experiences of the test taker. There is a general consensus that the major components of creative thinking processes and creativity are a knowledge base; general as well as domain-specific skills; metacognitive skills in planning, monitoring, and evaluation; and external or environmental stimuli. These cognitive and noncognitive components are essential for accessing and developing creativity.

4. Objective and Methods

Of the large number of instruments that have been developed to assess creativity, some are concerned with the cognitive processes involved in creative activities, others with the impact of the environment, and still others with personality factors such as attitude and motivation. There are also some that are particularly constructed to be sensitive to the effects of the testing process itself on creative behavior. The objective of the present study is to examine how teachers teach in ways that can effectively nurture students' creativity and how teachers help to improve the assessment of project making, produced by junior college students, by creative teaching methodologies.

To address both cognitive and affective needs, students who major in Engineering in junior college are selected as subjects to conduct the experiment of the newly designed project, building a rehabilitation apparatus.

The project, designed in two groups, mechanical and human affect, consists of three levels: Learning Basic Knowledge; Practicing Problem Solving; and Dealing with Real Problems and Challenges by conducting a project.

1. Learning Basic Knowledge
   - 1.1 Teaching students a number of fundamental knowledge of designing medical instruments for generating and analysing new ideas.
   - 1.2 Adapting divergent thinking tools, such as brainstorming, and attribute listing, to generate ideas of relevant knowledge.
   - 1.3 Illustrating pictures to analysing the relevant knowledge.
   - 1.4 Converging results by making inferences and deducing, deciding what information is relevant, thinking through analogies, using evidence, categorizing as the fundamental techniques.
2. Learning and Practicing Problem Solving
   Activities include practicing creative problem solving in a small group, consulting relevant academic and field experts, adapting techniques and knowledge acquired to evaluate the possible solutions.
3. Dealing with Real Problems and Challenges
   Divided the participants into to groups, mechanical and human affect, to implement the project.

The following metacognitive skills—planning, monitoring the thinking process, and evaluating outcomes—form the core of the project-making programme. It places great emphasis on the person or organic components of abilities, motivations, and cognitive styles; and it uses strategies that may be fundamental aspects in the production of novel and useful problem solutions.

5. Results and Evaluations

This research plans to contribute to develop creativity by an empirical research approach to examine how students generate creativity under teachers' instruction and stimulation. To manage this plan, the research progress by the way of leading student producing a project. Teachers would direct students how to set a case topic, at the meantime, increasing students' techniques and knowledge of creativity in the process of teaching. The goal sets on increasing fluency, flexibility, creativity and progress of sensing graphics and literate. After one year research on evoking creativity and one semester of teaching programme. It turned out that creativity is an ability that could be taught and developed. From the project sub-group 1, the test result before progress creative thinking and sequent showed that graphic and literate creativity increased. From the result of taking this project, the differences in progress show that graphic and literate creativity are increased.

		Average	Number of students	Standard difference
Graphic Creativity	Second Fluency Tolerance Test	16.87	27	4.54
	First Fluency Tolerance Test	12.37	27	4.38
	Second Flexibility Tolerance Test	11.16	27	2.69
	First Flexibility Tolerance Test	8.22	27	2.80
	Second Creativity Tolerance Test	12.94	27	4.29
	First Creativity Tolerance Test	9.46	27	5.57
	Second Progress Tolerance Test	2.90	27	2.43
	First Progress Tolerance Test	4.33	27	4.32
Literate Creativity	Second Fluency Tolerance Test	20.26	28	8.21
	First Fluency Tolerance Test	14.14	28	4.71

	Second Flexibility Tolerance Test	10.60	28	2.43
	First Flexibility Tolerance Test	8.57	28	1.81
	Second Creativity Tolerance Test	18.21	28	14.80
	First Creativity Tolerance Test	10.73	28	6.71

The research sub-groups subject to Industrial Junior College students, provide them hours classes of how to solve problems creatively, in open attitude offer sufficient time for students to think creatively. Use encouragement replaces of fault finding, enforce communication, and provoke attempt to courage and creative thinking stimulation. The evaluation result from real teaching case by means of its learning files, teaching observation records and written exam. After implementing the designated teaching methodologies, it made a dramatic effects on creativity of designing the structure and operating.

Analyzing on the research sub-group 2, the topic and content are similar, but illustration and description are different. The topic of develop creativity by means of structure design and operation reach the quality as well as the topic of develop creativity by means of artificial engineering and industrial design.

6. Findings and Evaluation on Project Results

According to the project research result and the student tolerance test, it shows that students have good progress on fluency, flexibility and creativity. Much of the time in learning should be devoted to dynamic interaction with knowledge via case studies, problem solving, and other inductive activities. Being knowledgeable as having a knowledge base that is conceptually well-organized and for which retrieval is fluent and efficient in relation to demand in a given problem-solving or creative thinking situation. Students being taught basic theories of creative thinking to enhance their metacognitive awareness of creative processes and to help them access their creativity. Through such understanding they can be led to greater control and effectiveness in creative thinking. Thus there is a set of metacognitive skills that can be taught and that are crucial elements of creative thinking and production. Emphasis should also be placed on creativity in domain- or subject-specific contexts. In addition, the environmental conditions should be arranged to be conductive to change, flexibility, and openness.

The research result demonstrated that the goal of prompt creativity quality of industrial college could be reached by the ways of teaching supported with project producing. Especially project producing, it provides an opportunity for student to implement a creative idea into practice during producing process. In this project, the first semester teaching activities reference several annual projects, the join employees expect that research developing creativity model could different from foreign method but suitable for domestic students, this is our common direction and goal that required to practice aggressively.

9. Reference

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