A study of a curriculum of pre-engineering technology education in Taiwan

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ABSTRACT: The purpose of this study was to explore senior-high-school technology teachers' viewpoints on a planned pre-engineering curriculum. First, a planned pre-engineering curriculum was drafted, and then a questionnaire was mailed to 110 technology teachers. Finally, 77 valid questionnaires were obtained, a return rate of 70%. The results of this study showed that the senior-high-school technology teachers had positive viewpoints in the planned pre-engineering technology education curriculum, but the technology teacher education institutes should put more emphasis on exploring the development trend in the future.

INTRODUCTION

The technology-oriented society needs more technological human resources and these human resources should be equipped with the abilities of problem solving, computer applying and information processing. Traditionally, these abilities were related to the learning of engineering, so if the students have the opportunity to learn the basic concepts of engineering, they should show great interest [1]. According to the present educational system in Taiwan, students have to acquire the related knowledge of engineering after they entered college or university. The situation was totally different in the United States, where students had the chance to learn the concepts of engineering through the learning of technology education. Hence, how to offer the engineering learning to our students before they enter colleges or universities became an important issue. It was also noticed that other countries would have the same problem and would need to find out an appropriate approach to solve this problem.

Kozak and Plummer argued that the emergence of new technology, the decline of technology teacher education programmes, and the transformation of engineering in an integrated discipline, all supported the idea that engineering or engineering technology could meet the schools' needs [2]. The annual conference of International Technology Education Association (ITEA) was held between 26 and 28 March 2009 in Louisville, Kentucky, and the most important issues included standard-related issues, interdisciplinary issues, design and making issues and engineering-oriented issues [3]. In light of these important issues being identified, it was not hard to establish that pre-engineering would be an important trend in technology education in the future.

On the topic of pre-engineering technology education curricula, Gomez proposed that students had the chance to develop their problem-solving competency through the learning under the pre-engineering technology education curriculum [4]. Therefore, the pre-engineering technology education curriculum was not focused on developing students as the future engineers, but just trying to equip them with the engineering-related literacy on the one hand, and multiple problem-solving competencies, on the other hand. In line with previous research, this study focused on exploring the technology teachers' viewpoints in the pre-engineering technology education curriculum, and the research results could be offered to other countries, should they wish to introduce a pre-engineering technology education curriculum to their own senior high school students.

To be specific, the research objectives were:

- to explore the technology teachers' viewpoints on the curriculum framework of a pre-engineering technology education curriculum, and
- to explore the technology teachers' viewpoint on the supplementary policies relating to a pre-engineering technology education curriculum.

LITERATURE REVIEW

In order to explore the technology teachers' viewpoints about the curriculum framework and supplementary policies of pre-engineering technology education curricula, a planned pre-engineering technology education curriculum was developed according to the literature review.

The Framework of a Pre-Engineering Technology Education Curriculum

The curriculum framework of a pre-engineering technology education curriculum could be divided into five aspects that were goal, content, participant, implementation and assessment.

According to the goals of the *Principles of Engineering* [5], the pre-engineering technology education curriculum at Grandville High School [6] and the Standards for Technological Literacy [7], the curriculum goals of a pre-engineering technology education curriculum should be focused on initiating students' interests in engineering and technology, teaching students to solve practical engineering problems according to the procedures of engineering design and increasing students' technological literacy in engineering.

The National Research Committee on Science Standard and Assessment suggested that developing students' understandings in the concept of engineering at elementary and secondary school levels was an important task for technology education. Therefore, according to the contents of the *Principles of Engineering* [5] and *the Design Technology and Engineering for American's Children* (DTEACH), ten major contents should be included in the pre-engineering technology education curriculum. These are:

1. the decision-making method for solving problems in a technological world;
2. to collect and plan resources in different engineering fields;
3. the creation and innovation in engineering fields;
4. the design procedure of solving problems in engineering fields;
5. to describe the process of engineering system by utilising the texts and graphs;
6. the technique of computer simulation or modelling;
7. the process of searching for the best problem-solving method;
8. the analytic process of the engineering system;
9. the impacts of engineering fields on humans, society and the environment;
10. the utilisation and evaluation of modern engineering technology.

Most engineering education was offered only at the university or graduate school level, and this was because engineering was the beginning of a special and professional course [8]. Meanwhile, in the 1990s, many research results in the United States and elsewhere suggested that the concept of engineering should be included in the learning of technology education. The *Principles of Engineering* document in New York was reviewed by the state government, and was one of the courses in technology education selected for grade 9 to 12 students [9]. In addition, the Montgomery Country Public Schools (MCPS) in Maryland offered the pre-engineering technology education curriculum to grade 10 to 12 students [10], and the Grandville High School also offered the pre-engineering technology education curriculum to grade 11 to 12 students [6]. Therefore, the participants would usually be in grades 11 and 12, according to the reviewed literature.

Gloeckner stated that technology education helped students in acquiring hands-on competency in the fields of engineering and natural science, and students could have the chance to practice and extend their own competency in mathematics and science through dealing with practical real-world problems [11]. Dugger also argued that the technology teachers had the responsibility to develop students' concepts of engineering in technology education [12]. Therefore, the best way to teach students the basic concepts of engineering was through technology education according to previous scholars' viewpoints.

Dugger proposed that the members in the fields of engineering and technology education should place their emphasis on the development of assessment tools for the purpose of exploring students' learning performance [12]. According to the planning of assessment in the *Principles of Engineering* [5], the following assessment methods should be included:

1. the real situation of course discussion between technology teachers, students and groups;
2. students' resources collection according to the engineering problems;
3. students' proposed plans according to the engineering problems;
4. students' process and results in designing and making model;
5. paper and pencil tests that were related to the concepts of engineering.

Therefore, the assessment of a pre-engineering technology education curriculum should utilise multiple assessment methods, and the technology teachers should have the chance to explore students' learning performance.

The Supplementary Policies Relating to a Pre-Engineering Technology Education Curriculum

The implementation of a curriculum was related to the curriculum change factors, school and district factors, external factors, the educational administration, school administration and teacher education, where the last three were the major supplementary policies according to the previous factors [13].

Teachers were the key factor in education, and technology teachers also had an important role in encouraging and maintaining students' interest in learning mathematics, science, technology and engineering [14]. In order to offer the pre-engineering technology education curriculum to students in senior high schools, the technology teachers' on-job training and competency should be emphasised. For the technology teachers' on-job training, the technology teacher education institutes should work with technological museums and develop a complete training plan. Besides, the educational administration should also offer funds to support all training plans. As for the technology teachers' competency, the New York State Education Department [5] believed that technology teachers should be equipped with the following basic competencies for teaching the pre-engineering technology education curriculum:

1. to study physics and chemistry at university;
2. to study trigonometry in calculus;
3. to have computer literacy;
4. to have professional drawing experience (e.g. CAD);
5. to have hands-on experience in designing and constructing model; and
6. to participate in the on-job training courses for teaching the pre-engineering technology education curriculum.

In the supplementary policy of school administration, the learning environment and course scheduling were two major factors in offering the pre-engineering technology education curriculum. For the learning environment, the New York State Education Department described the learning environment of the *Principles of Engineering* as: (1) space must be provided in a technology laboratory and equipped with sufficient tools and materials for all students; (2) the woodworking, metalworking and electronic working tools should be included; (3) there should be computer facilities for designing and solving problems [5]. As for course scheduling, the pre-engineering technology education curriculum should be scheduled in one semester and be worth two credits, and this was in agreement with the real situation in Taiwan.

With the challenge of new technologies and educational reforms, technology teacher education had to change in line with the new policies and society. In the supplementary policy of technology teacher education, the new teaching ideas' communication methods and the new model of curriculum and teaching should be considered. For new teaching ideas' communication methods, the technology teachers had to communicate with the members in the field of science and engineering in order to create the opportunity to learn the concepts of engineering through the technology laboratory. As for the new model of curriculum and teaching, more and more position papers put their emphasis on developing an integrated mathematics, science, technology and engineering (MSTE) curriculum and exploring the effects on students' cognitive learning achievements [15]. Therefore, technology teacher education should also take into account of this trend and put MSTE into their training courses.

RESEARCH DESIGN

Research Methods

This study focused on exploring technology teachers' viewpoints about a planned pre-engineering technology education curriculum. A literature review and a panel discussion were employed to develop a questionnaire on pre-engineering technology education curriculum and a questionnaire survey was employed in order to explore the technology teachers' viewpoints in the planned pre-engineering technology education curriculum.

Participants

There were 153 senior high schools in Taiwan according to the Ministry of Education's data in 2000. This study utilised stratified random sampling in choosing the participants, and 110 senior high schools were selected with one technology teacher from each selected to be the participants. The researcher mailed 110 questionnaires on 10 April 2001, and 77 effective questionnaires were returned, giving a return rate of 70%.

Research Tools

The major research tool was the questionnaire, and the content validity and Cronbach α were utilised in confirming the validity and reliability. For the content validity, a president of a technical college with a major in engineering, a professor from a national university with a major in technology education and three technology teachers from senior high schools were invited to join a panel discussion for the purpose of revising the questionnaire. As for the Cronbach α analysis, the overall questionnaire's α value was 0.95, the curriculum framework *scale's* α value was 0.94, and the

supplementary policies' α value was 0.90. Therefore, the questionnaire, which was developed in this study, was equipped with good validity and reliability.

RESULTS AND DISCUSSIONS

In order to explore technology teachers' viewpoints of the curriculum framework and supplementary policies, the *Likert scale design* was employed to analyse the questionnaire for the purpose of determining technology teachers' viewpoints in the curriculum framework and supplementary policies.

The Curriculum Framework of a Pre-Engineering Technology Education Curriculum

According to the data analysis results shown in Table 1 is that most technology teachers thought that the curriculum goals, which were planned in this study, were important, particularly if they were focused on initiating students' interest in engineering and technology, and solving practical engineering problems according to the process of engineering design. Therefore, most technology teachers were concerned about the issues of motivation and practical skills in learning the pre-engineering technology education curriculum.

Also shown in Table 1 that most technology teachers thought that the contents of the decision making method in solving the problems of the technological world, and the impact on humans, society and environment in engineering field were more worthy of learning in the pre-engineering technology education curriculum. Therefore, how to teach students in making decisions and reflecting on the impacts of engineering fields was an important task for technology teachers.

Forty-five technology teachers (58%) thought that the participation in the pre-engineering technology education curriculum should be planned for students in grades 10 or 11. These results corresponded with those from the Montgomery Country Public Schools' survey, which suggested grades 10 to 12 [10], and the Grandville High School's survey, which preferred grades 11 to 12 [6]. Therefore, according to the results of data analysis and the literature reviewed, grade 11 students were considered to be the best choice.

Table 1: Technology teachers' viewpoints on the curriculum framework.

Curriculum framework	*M*	*SD*	unimportant ⟷ important				
			1	2	3	4	5
Goal							
1. To initiate students' interest in engineering and technology	3.94	1.03				∨	
2. To solve practical engineering problems according to the process of engineering design	3.71	1.06				∨	
3. To understand the relationships between the mathematics, science, technology and engineering	3.57	0.92			∨		
4. To enhance students' technological literacy in engineering	3.56	0.86			∨		
5. To understand engineer's career	3.49	0.91			∨		
6. To understand the pathway of engineering education	3.47	1.01			∨		
Content							
7. The decision making method in solving problems of the technological world	3.78	0.87				∨	
8. The collection and planning of resources in different engineering field	3.58	0.82			∨		
9. The creation and innovation in engineering fields	3.53	1.05			∨		
10. The design process of solving problems in engineering fields	3.40	0.94			∨		
11. To describe the process of engineering system in utilising the texts and graphs	3.48	0.88			∨		
12. The technique of computer simulations and model	3.51	1.10			∨		
13. The process of searching the best solution	3.62	0.97			∨		
14. The analysis and operation process of engineering system	3.22	0.95			∨		
15. The impacts for humans, society and environment in engineering field	3.69	0.92				∨	
16. The utilisation and assessment of modern engineering technology	3.55	0.79			∨		
Assessment							
17. The real situation of course discussion between technology teachers, students and groups	3.64	0.86			∨		
18. Students' resources collection according to the engineering problems	3.48	0.94			∨		
19. Students' proposed plans according to the engineering problems	3.45	0.98			∨		
20. Students' process and results in designing and making model	3.55	0.98			∨		
21. The paper and pencil tests that were related to the concepts of engineering	3.13	0.69			∨		

According to the results of the survey questionnaire, 34 technology teachers (44%) thought that the pre-engineering technology education curriculum should be planned as an optional course. However, 20 technology teachers (26%) argued that the pre-engineering technology education curriculum should be planned as a required course. Therefore,

most technology teachers believed that it was more appropriate that the pre-engineering technology education curriculum should be offered to students as a selected course.

According to the results shown in Table 1, the better methods in assessing students' performance in learning pre-engineering technology education curriculum were to explore the real situation of course discussion between technology teachers, students, and groups, and to understand the students' process and results in designing and making models. This also showed that the technology teachers put more emphasis on attitude and skills instead of cognition of the concepts of engineering.

The Supplementary Policies of a Pre-Engineering Technology Education Curriculum

The educational administration staff were included in the teachers' competency and on-job training. For the teachers' competency, most technology teachers thought that computer literacy was the most important competency in teaching the pre-engineering technology education curriculum. On the other hand, competency in chemistry, calculus and civil engineering were less important in teaching the pre-engineering technology education curriculum. As for the on-job training needs, most technology teachers though that the on-job training in the field of engineering was a better choice than mathematics or education.

The school administration staff were included in the planning of course credits and duration, and the need for facilities. For this planning, 58 technology teachers (75%) thought that the pre-engineering technology education should be planned as 2 credits programme, and 43 technology teachers (56%) thought that the pre-engineering technology education curriculum should be planned over two semesters. As for the need for facilities, most technology teachers did not want to teach the pre-engineering technology education curriculum in their present technological laboratory, and most technology teachers thought that they needed more computer facilities in teaching students how to design and solve problems.

According to the results of the survey questionnaire, most technology teachers thought that teacher education should put the emphasis on developing students to major in technology and minor in mathematics instead of the integration of mathematics, science and technology. But according to the current trend in international technology education, the integration of mathematics, science and technology was very important. Foster proposed the importance of subject-matter integration [16], and Davies and Gilbert stated that the integration of science and technology could retrieve the shortcomings of a lack of theory in technology and practical skills in science [17]. Therefore, planners and designers of teacher education should rethink this issue carefully.

Table 2: Technology teachers' viewpoints on supplementary policies.

Supplementary policies	*M*	*SD*	unimportant ←→important				
			1	2	3	4	5
Educational administration: teachers' competency							
1. To equip with the university level's physics competency	3.90	0.80				∨	
2. To equip with the university level's chemistry competency	3.40	0.85			∨		
3. To equip with the university level's calculus competency	3.49	0.87			∨		
4. To equip with the computer literacy	4.35	0.76					∨
5. To equip with the professional drawing competency (CAD)	3.91	0.75				∨	
6. To equip with the competency of research and design in technological fields	4.06	0.78				∨	
7. To have experiences in designing and making model	3.96	0.88				∨	
8. To understand the basic knowledge of electrical engineering	3.88	0.73				∨	
9. To understand the basic knowledge of electronics engineering	3.83	0.71				∨	
10. To understand the basic knowledge of mechanical engineering	3.82	0.74				∨	
11. To understand the basic knowledge of civil engineering	3.61	0.81			∨		
Educational administration: teachers' on-job training							
12. Mathematics' need	3.61	0.85			∨		
13. Engineering's need	4.30	0.83					∨
14. Education's need	3.36	1.01			∨		
School administration							
15. To adopt the present technological laboratory	2.97	1.14		∨			
16. To offer sufficient tools and materials for all students	3.45	1.13			∨		
17. To offer different hands-on tools to students in making models	3.66	1.07			∨		
18. To offer computer facilities for designing and solving problems	3.81	1.10				∨	
Teacher education							
19. The integration of technology, science and mathematics	3.31	0.88			∨		
20. The major is technology and the minor is mathematics	3.77	0.74				∨	

CONCLUSIONS AND SUGGESTIONS

According to the previous data analysis and discussions, the following conclusions were made:

- The technology teachers had positive viewpoints in the planned pre-engineering technology education curriculum. Technology teachers thought that the curriculum framework and supplementary policies were mostly important to offer the pre-engineering technology education curriculum to students. Therefore, the planned pre-engineering technology education curriculum could be taken as an important reference when Taiwan or other countries want to offer this curriculum to their students.
- The technology teacher education institutes should put more emphasis on exploring the development trend in the future. The only difference between technology teachers' viewpoints and those in the literature related to the teacher education model is that the technology teacher education institutes should put more emphasis on exploring the development trend in the future. Zuga argued about the importance of integrating science, mathematics and technology education in teacher education programmes, and she was also convinced that this idea was not viable [18]. Therefore, the technology teachers' viewpoint in teacher education was worthy of reflecting and discussing carefully in the near future.

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