A creative thinking teaching model in a computer network course for vocational high school students

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ABSTRACT: With the coming of the age of the knowledge economy, the cultivation of a future workforce should place emphasis on the ability for innovation. The objective of vocational education is to prepare the human resources needed by industry in order to enact social structural change in the age of the knowledge economy. Therefore, identifying how to develop the ability to innovate in students has currently become an important issue for vocational education. In this article, the authors first discuss the current teaching situation of a computer network course at a vocational high school. They then develop creative thinking teaching strategies after perceiving the common teaching problems for the cultivation of students' creative thinking abilities in a computer network course. After implementing this model, a teaching satisfaction survey questionnaire was carried out in order to gain feedback concerning this teaching model. The main purpose of this study was to realise students' perceptions on cognitions, skills, affections and creativities. It is considered that the results of the teaching satisfaction survey questionnaire conducted could supply answers regarding this matter.

INTRODUCTION

In engineering education, various educators have proposed the need for a high level of achievement in order to gain an understanding of the economic and environmental consequences of the professional tasks [1]. This requires that engineering students must be able to bridge this gap through their knowledge and creative abilities [2].

Several engineering researchers have illustrated the results of creative processes and proposed that personal experiences aid in evaluating creativity [3]. Therefore, creativity should expose all thinking parameters, rather than for just a specific pattern, in order to develop wider and more responsive skills, to revisit the ability, and to discover that creative thinking for engineering problems is important.

In order to understand the creative function, it is necessary to consider engineering students' educational backgrounds. According to the research, students who had a dominant natural flair for creativity tended to find success in the arts and would move away from logical deductive subjects, such as engineering [4]. This indicates that most engineering students find creativity to be hard work because such reasoning is unnatural to their normal way of thinking. Verner suggested that engineering educators could not ignore the deficiencies in the prerequisite knowledge and skills of their students, especially in their thinking patterns [5].

Based on this rationale, the main purpose of this study was to propose teaching strategies to develop a creative thinking teaching model in order to enhance students' creative thinking abilities in a computer network course. However, before developing a suitable creative thinking teaching model, several key issues should be examined, such as the current teaching settings, strategies, climate and the knowledge essence of the specific discipline. Therefore, the creative thinking teaching model would not only need to improve the current creative thinking teaching practice at vocational high schools, but also be able to achieve the teaching objectives of a computer network course at the same time, rather than consider them separately. Afterwards, the content knowledge in computer networks and creative thinking techniques should also be added in this teaching model. Upon finishing this model, a panel discussion was conducted to modify the model.

After constructing this teaching model, teaching activities were held to educe students' creative thinking abilities in a computer network course. Another main purpose of this study was to realise students' perceptions about the effects of the model on students' learning in terms of cognition, skills, affections and creativities. A learning satisfaction survey questionnaire was the main tool used to elicit these answers in this study.

PURPOSES

According to the above mentioned research background, the main purpose of this study was to develop a suitable creative thinking teaching model and to understand students' satisfactions of the teaching model. This combines several creative thinking strategies with regard to students' creative thinking abilities in a computer network course offered at vocational high schools. The research had the following objectives:

- To survey the current circumstances of creative thinking teaching;
- To develop a creative thinking teaching model in a computer network course for vocational high schools after analysing the current practice through a survey questionnaire;

- To realise students' perceptions of this teaching model and their responses regarding cognition, skills, affections and creativities.

LITERATURE REVIEW

Creative Thinking Techniques

The creative thinking teaching model focuses on teachers helping students to construct their creative abilities during the process of conceptual changes. But can creativity be taught? Teaching creative thinking is a complex task and cannot be illustrated only in a specific behaviour or fragment knowledge [6].

Creative thinking teaching strategies can first be considered from the viewpoint of the knowledge essence of the discipline and professional ability performance. To accomplish the creative thinking teaching strategies in a computer networks course, a variety of creative thinking techniques should be examined. These include

- Brainstorming;
- 6W;
- SCAMPER;
- Attribute listing;
- Morphological analysis;
- Synectics [7][8].

The characteristics of the various examined creative thinking techniques are elaborated on in Table 1 [9].

Computer Networks Course

Computer networking is a discipline that focuses on the study of communication structures, such as interface, connecting media, flow and error control, and access and routing algorithms [6]. The teaching of computer networks at vocational high schools emphasises alternative approaches, such as the layered approach that accents network architecture, protocols and implementation.

Architecture

Computer network architecture is the structure that determines how the various logical and physical components of a network are interconnected. In order to reduce design complexity, modern networks tend to utilise layers to perform certain functions. In this course, the focus is on the bottom layer: the physical layer.

The physical layer features communication functions, such as the number of connector pins and hardware components. However, hardware equipment is not the only way to implement networks. Knowledge of the physical layer stresses the realisation of the characters of every component and signal, as well as modifying them so that they can have other uses.

Protocols

The functions of protocols are a well-defined set of rules for each level to carry out its conversation in an orderly and structured manner, when users communicate in different network nodes. The rules of protocols are formulated according to the International Organization for Standardization (ISO).

At this time, teaching strategies can focus on the innate character of protocols. Some questions can be posed for students to think about various key issues, which may include:

- Why do you need protocols?
- What should these protocols do?
- How should these protocols be carried out?

Implementation

In the science field, the most important element in the design of creative experiments is professional knowledge. In order to let learners acquire related knowledge, skills, attitudes and creative abilities, a suitable learning setting needs to be created.

The next project, after realising computer network architecture and protocols, involves getting students to integrate their knowledge and present a possible function of a network. The task of the teacher is to develop a problem-solving task for students so that students can enhance their abilities regarding the techniques for the exchange of network nodes.

Students need to consider the physical limitations of different types of networks and the transmission media in connecting the nodes of local network users. In order to illuminate students' creative thinking abilities in computer networks, some special thinking processes were utilised to show the factors relating to the problem, and provide students with feedback concerning their thinking abilities. In order to carry out a computer network project, students should consider the following steps:

Table 1: Characteristics of the various creative thinking techniques.

Author(s)	Method	Characteristics
Osborn	6W	Using why, when, who, what and how: 6W questions to spur specific ideas
Michalko & Eberle	SCAMPER	Rearranging 6W questions into the mnemonic SCAMPER (Substitute, Combine, Adapt, Modify, Put to other uses and Eliminate)
Osborn	Brainstorming	Generating ideas in a group situation can be better than an individual effect.
Crawford & Morgan	Attribute Listing	Breaking the problem into its component parts and developing a list of ideas to improve each one.
Koberg, Bagnall & Zwicky	Morphological Analysis	As above, but focusing on independent systems.
Garder	Synectics	Coming from the Greek word *synectiko*, which means *bringing different things into unified connection*; all things, regardless of their dissimilarity, can somehow be linked together in either a physical or symbolic way.

- Investigation and analysis;
- Selection and design;
- Implementation;
- Operation and management.

Creative thinking strategies that could be used here include brainstorming, attribute listing and synectics. The procedure of this work could also permit students to express their professional abilities and carry out their projects.

Implementation of Creative Thinking Teaching in a Computer Networks Course

Following the principles of creative thinking teaching strategies, the prerequisite knowledge of computer networks for students and the suggestions of the expert panel discussion, the teaching model was identified; this is listed in Table 2 [9].

The purpose of the architecture is to simplify the operations when data communication operates in a computer network. Each architecture layer has its own characteristic function to finish the complex technological process. In the relational hierarchy, the teaching strategy is focused on each layer function. The protocols are the regular pattern for the entire firm to develop their networking products. The teaching objective of protocol analysis is to get students to think about the knowledge essence of the protocols. Implementation refers to the application, which required students to apply the knowledge to solve certain problems. The activity of teaching addresses group interaction.

Teaching Satisfaction Survey

Evaluation is another important issue for education. A teacher always wants to use a test as quickly as possible in order to be able to prove the effect in the class, with the involvement of students. Such a test is the single way to evaluate students' cognitive performance.

In this study, it is assumed that this creative thinking teaching model could cultivate students' creative abilities simultaneously with professional knowledge so that they could integrate creative thinking into professional knowledge to generate new ideas and values. For this purpose, this study's focus was not only to realise students' cognitive performance, but also to understand their skill responsibilities, affections and creativities. These four dimensions were the criteria utilised in order to assess this teaching model through the satisfaction questionnaire.

METHODOLOGY

Procedures

Before executing this satisfaction survey, many elements still had to be realised, such as current teaching circumstances, the implementation of a lesson plan, as well as teaching activities. This research procedure is shown in Figure 1.
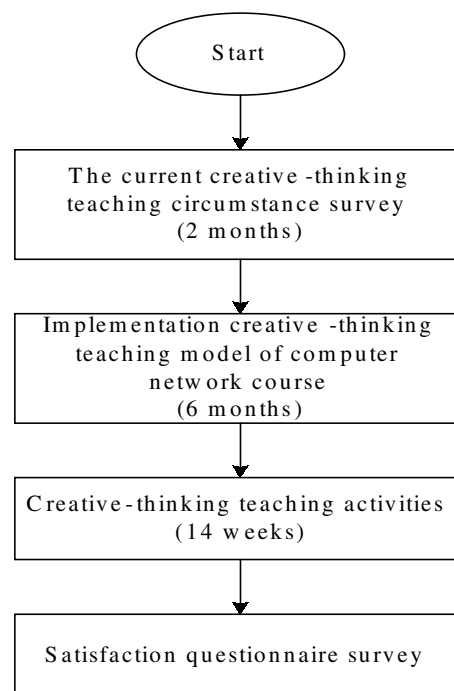

Figure 1: Research flow.

In order to realise the creative-thinking teaching model in a computer network course, the authors considered many creative-thinking techniques in teaching activities. One of these teaching activities is listed in Table 3.

Table 2: The creative thinking teaching strategies for computer networks.

Curriculum Frame	Strategy Name	Activities Criteria
Architecture	SCAMPER Attribute listing Morphological analysis	• Determine the function of physical components; • List the main attributes of each component; • Break down, combine, modify and rearrange the problem into its component parts; • Think of any way to improve the function of the components.
Protocols	6W questions	• Why were protocols necessary? • When should the protocols be undertaken? • Where were the protocols carried out? • Who should engage them? • What should the protocols do? • How should the protocols be carried out?
Implementation	Brainstorming Synectics Attribute listing	• Pool ideas; • Check ideas within the group; • Bring different ideas into a unified connection; • Make approach ideas become possible to solve.

Table 3: A creative-thinking teaching activities lesson plan.

Lesson Topic	Protocol
Purpose	Reinforcement of computer network concepts and discovery of hierarchical ordering
Objective	The objectives seek to focus students' understanding on how network communications work. How communication systems operate will be explained to students. A variety of transmission tools that transmit the data across networks will also be described.
Material	Computer network textbook
Procedures	• Why are protocols necessary? • Examination of what happens when two computers exchange data communication; • How does the communication system operate? • What should the protocol do? • Protocol specification and verification; • Who defines the protocol and how is this carried out? • Explanation of OSI versus IEEE standardisation, etc.
Reflections	Students enjoyed this teaching activity. They tried to address their thinking of what was asked. The lesson was successful because all students engaged all questions.

Interview Survey

Before constructing this model, some vocational high schools were first interviewed in order to ascertain the current creative thinking teaching situation. The focus was on statements that also help to improve current settings, including creative teaching problems, equipment or resources, teaching strategies and the teaching climate. These statements include the following:

• Identify current teaching problems in the computer network course;
• Determine current teaching equipment and resources;
• Detect current creative thinking teaching strategies;
• Identify the interaction between teachers and students during the creative thinking teaching process.

Instruments

Two research instruments were utilised in this study. These include a current creative thinking teaching circumstances questionnaire and a learning satisfaction survey. The purpose of these two instruments was to measure the learning satisfaction of students about the developed teaching model in a computer network course. Experts' recommendations were used to judge if these two survey questionnaires had a content validity.

Current Circumstances Questionnaire Survey

In order to implement this creative thinking teaching model in a computer networks course, the researchers adopted a questionnaire and held an expert panel discussion in order to establish the framework and key steps. A number of key dimensions were included in this survey questionnaire, and they were used to achieve one of the research objectives. These four dimensions are listed as follows:

• What are the current school settings of creative thinking teaching? Was an orderly and supportive environment established for the teaching of creativity?
• Are there resources ready for creative thinking teaching? This includes instructional tools, teaching materials and colleagues' willingness to teach in a new style.
• How is the creative thinking teaching strategy run? Are students stimulated to think or design via a wide variety of activities that engage them in constructive learning? Have suitable assessment methods been developed to improve these activities and goals?
• Is attention paid to the interaction between teachers and students? How is this achieved?

Creating a Satisfaction Survey Questionnaire

Four dimensions needed to be realised to identify students' perceptions regarding this creative thinking teaching model, namely: cognitions, skills, affections and creativities. Each dimension has several associated questions that are listed below:

• *Cognitions*: Acquiring new concepts; promoting conceptual understanding, applications and integration; and promoting learning effects.
• *Skills*: Promoting the framing of questions and thinking skills; saving learning time; and promoting problem-solving abilities.
• *Affections*: Having more opportunities to infer problems, increase emotions and learning motivations and promote interactions with classmates and teacher.
• *Creativities*: Having exciting creative concepts and ideas; and promoting flexibilities and consideration thinking.

FINDINGS

A 5-point scale was utilised to rank these conditions in the statements of the current creative thinking teaching practices. The results are shown in Table 4 [9]. The results indicate that the teachers were willing to reinforce creative thinking teaching, but the general situation was not necessarily favourable for them. Based on these findings, this study developed a suitable teaching model to meet their needs, which is shown in Table 2.

Table 4: The current teaching circumstances survey.

Question Dimension	Mean	SD
Current creative thinking teaching settings	3.02	0.51
Current creative thinking teaching resources	3.11	0.54
Current creative thinking teaching strategies	3.80	0.44
Interactions in creative thinking teaching classroom	3.80	0.41

Again, a 5-point scale was used to rank the satisfaction questionnaire and the results are shown in Table 5. According to these results, the four dimensions of the teaching satisfaction questionnaire were cognitions (mean = 3.98), skills (mean = 3.90), affections (mean = 4.12), and creativities (mean = 3.91). These results illustrate that the creative thinking teaching model

did meet the needs of students' cognitions, skills, affections and creativities learning in a computer network course.

Table 5: Analysis of the teaching satisfaction questionnaire survey.

Dimensions	N	Mean	SD
Cognitions	27	3.98	0.57
Skills	27	3.90	0.65
Affections	27	4.12	0.56
Creativities	27	3.91	0.67

CONCLUSIONS

This research included the understanding of the current creative thinking teaching settings, reviewing the creative thinking teaching strategies and clarifying the concepts of creativity. In order to enhance students' creativity, it is necessary to discuss the knowledge essence of creative thinking and to cultivate students' comprehensive perspectives of such matters after implementing this creative thinking teaching model.

Emphasising activities or strategies that should be implemented in the classroom is not enough. The effective teaching of creative thinking should consider how to match the essence of the knowledge and the method of creative thinking teaching. Equipping teachers with creative thinking teaching abilities might also be helpful [10][11]. Shared perspectives and shared knowledge were found to be the key points in building a successful creative thinking teaching strategy. Quasi-experimental research may be a future research method that can be undertaken in order to identify its learning performance.

ACKNOWLEDGEMENTS

REFERENCES

1. Institution of Engineers, Australia (IEAust), Educating Engineers for a Changing Australia. Canberra: IEAust Report (1996).
2. Besterfield-Sacre, M., Atman, C.J. and Shuman, L.J., Engineering student attitudes assessment. *J. of Engng. Educ.*, 87, **2**, 133-141 (1998).
3. Thompson, G. and Lordan, M., A review of creativity principles applied to engineering design. *Proc. Institution of Mechanical Engineers*, London, 213, **1**, 17-31 (1999).
4. Court, A.W., Improving creativity in engineering design education. *European J. of Engng. Educ.*, 23, **2**, 141-154 (1998).
5. Verner, I.M., Waks, S. and Kolberg, E., Educational robotics: an insight into systems engineering. *European J. of Engng. Educ.*, 24, **2**, 201-212 (1999).
6. Hammond, J.L. and O'Reilly, P.J.P., *Performance Analysis of Local Computer Networks.* Reading: Addison-Wesley Publishing Co. (1988).
7. Evans, T.D., Encouragement: the theory to reforming classrooms. *Educational Leadership*, 54, **1**, 81-85 (1996).
8. Shaunghnessy, M.F., *On the Theory and Measurement of Creativity.* (ERIC document reproduction service no. Ed 381576) (1995).
9. Hsiao, H-C., Liang, Y-H. and Lin, T-Y., Integrating creativity into computer networks course teaching. *Proc. 7th Baltic Region Seminar Engng. Educ.*, St Petersburg, Russia, 125-128 (2003).
10. Glazer, S.M. and Ogle, D. Helping our students see their learning. *Teaching. PreK-8*, 25, **2**, 100-102 (1994).
11. Osborn, A.F., *Applied Imagination.* New York: Charles Scribner's Sons (1953).

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