How To Utilize the Mindmaps To Facilitate Problem-finding Attitude of the Engineering Students In a Creative Mechanical Design Course

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Abstract *¾ This study was conducted to explore how creative problem-solving processes and divergent thinking can be closely integrated and taught, and what are the factors to enhance students' ability for creative learning.*
One research question was investigated: What were the qualitative differences between the case study and the mind-mapping on students' attitudes and perceptions? Observation, a questionnaire, and interviews collected data on classroom activities and teachers' efforts to foster student creativity. It was found that teacher participation, classroom interactions, classroom atmosphere, comprehension of teaching materials, and students' involvement were significant factors that influenced students' creative learning.

INTRODUCTION

The majority of creativity research has tended to emphasize the cognitive dimensions of learners' to creativity (e.g. mental ability factors, tactics, strategies, and so forth). Accordingly, educators have followed the lead of the current academic emphasis in field by focusing on the cognitive problems of students, rather than providing information that could suggest how creative learning might be made more enjoyable, meaningful, and productive. Some efforts have been made to combine both cognitive and affective aspects in relation to learning and development (Watts & Alsop, 1997; and Snow, et al, 1996). However, an imbalance between these two dimensions may account for some of the perceived needs and problems experienced by learners.

Students' perceptions of course content are important, since if students enjoy the classroom activities, they tend to be more motivated to actively engage with their work, and thus derive more value and learning throughout the process (Palmer, 2000). For example, positive student interest is likely to be seen as an important goal of instruction because it is an important aspect of readiness to learn. Indeed, such an attitude is a goal precisely because it is an aspect of readiness for future learning, as well as of appreciation of a subject matter domain for its own sake (Snow et al, 1996).

It is further known that positive affect induced during learning enhances meaningful cognitive organization and processing. Happy students maybe be more likely to encode new information in ways that connect this information more fully and flexibly to existing knowledge in creative ways, and to modify existing knowledge organization in the process (Isen, Daubman & Gorgoglione, 1987). This encoding enriches and thus facilitates learning and problem solving. In other words, a positive affect may be an aptitude for meaningful learning and problem-solving situations. Finally, students' perceptions of the course content are important, since if students enjoy the classroom activities, they tend to be more motivated to actively engage with their work, and derive more value and learning throughout the process (Palmer, 2000).

Therefore, this research argues for the necessity to understand the role that affect plays in motivating engineering students to learn. Specifically, this study was conducted to discover how affect can influence both problem solving and problem finding processes of engineering students in a creative mechanical design course.

BACKGROUND OF THE PROJECT

Basically, the course allowed students to experience first-hand the reality of applying creative and technical skills to the world outside the academic environment. Students built prototypes themselves, presenting a project as professionals, so they worked late hours driven by their own excitement and by the expectation of reaching a result. The survey results for the last three years have indicated that the impact of such an open-ended project-based course extended beyond the enhancement of mechanical competence and that it has provided students a sense of achievement and satisfaction (Chang, 2000; Hsiau, 1998). Yet, the vulnerability caused by their inadequate problem finding skills have also tended to create unpleasant feelings of frustration. Hence, it is crucial to understand student variations in attitude, motivation, and perceptions in order to adapt instruction to the strengths, weaknesses, preferences, and predictions of different students (Snow et al, 1996).

Enhancing creative problem-finding confidence by mind-mapping activity

Based on the experiences with this course over the past three years, it seems crucial to stress the significance of problem-finding skills for encouraging engineering students to seek new experience. Throughout their years of formal education, students were asked to engage in convergent rather than divergent thinking (Cole, et al, 1999). However, tomorrow's engineering challenges are more likely to contain elements of personal, social, or technical diversity as part of the data to develop solutions that are both creative and effective.

Cognitive theorists believe that when we think consciously about an issue, our previously training and the effort to arrive at a solution push our ideas in a linear direction, usually along predictable or familiar lines (Csikszentmihalyi, 1996). In contrast, free from rational direction, ideas can combine and pursue each other in various ways. Because of this freedom, original connections that would be at first rejected by rational thought processes have a chance to become established.

In the affective domain, however, what helps to preserve and develop individuality, and therefore enhance creativity, is an environment that we have built to reflect ourselves. Here it is easy to block out external distractions and develop creative environments where information from different perspectives can be exchanged and synthesized. In addition, the importance of teachers, peers, and mentors, to help along the development of creative individuals has been examined in Mockros and Csikszentmihalyi (1995) , Wigner (1992), Hersh and John-Steiner (1993). Of course students need external incentives, such as grades, to take the first steps. Most enjoyable activities, such as learning, are not natural; they demand an effort that, initially, students may be reluctant to make. But once the students become focused and the activity provides a pleasure inherent within the activity itself, the activity itself begins to be intrinsically rewarding (Csikszentmihalyi, 1990).

Therefore, the purpose of instructional activities for this course was to nurture students' individual interests, arrange classroom conditions to emphasize intrinsic rewards, and to minimize extrinsic pressures for competition, grades, and rules.

Mind-mapping activity

Students must constantly face intellectual challenges posed by concrete problems associated with past knowledge and personal experience in order to develop increased motivation and to make learning an enjoyable process (Csikszentmihalyi, 1996). The mind-mapping activity is a non-competitive intellectual stimulating assignment to enrich students' understanding of the divergent thinking. It not only creates opportunities for students to learn from one another, but also enables students to participate and interact. The emphasis of the approach is to take responsibility as an active learner and to develop the ability to find questions and make comments about the projects. Therefore, the mind-mapping activity was used to develop students' ability to approach their projects when they are not initially sure what they want to do. In fact, this kind of open-ended process that leads to discovery was the most important problem finding process described by creative individuals (Runco, 1994).

TABLE 1

FREQUENCY OF CODED INTERVIEW DATA ACCORDING TO SIX FACTORS AFFECTING STUDENTS' ATTITUDES AND PERCEPTIONS OF INSTRUCTIONAL ACTIVITIES

	Factors	Frequency
1	Enhancement of Creativity	30
2	Cooperative Learning	22
3	Participation of Teacher	44
4	Classroom Atmosphere	18
5	Comprehension of Instructional Activity	14
6	Self Self-Involvement	26

First of all, the teacher introduced the components of mind-mapping. The best way to convey the significance of this activity is to show the role it plays in an overall problem-finding process, including examples which show application of divergent thinking skills in current professional practices. After introducing students to the mind-mapping done by the Boeing Aircraft Company, the Digital Computer Company, etc., students were encouraged to produce an individual mind-mapping. Next, the group mind-mapping was conducted within the group after students' initial experience to the principles of mind-mapping. The topic used for the group activity came from the project they intended to design for the rest of the semester. It is through this kind of reflection and discourse that a future engineer can learn from his or her own experience and continue to develop as a knowledgeable practitioner. While the students may not have adequate knowledge as individuals, as a group they have an extensive body of knowledge. Methodology

The collections and analyses of the results of this research were organized to one question:

What were the qualitative differences between the case study and the mind-mapping on students' attitudes and perceptions?

Three evaluation methods, including interviews, and students' written feedback were used to explore the role of affect plays in motivating engineering students to grow.

First of all, an interview protocol was developed to assess student responses toward course content and classroom activities. The interview questions were an open-ended, semi-structured format that focused upon finding evidence to provide explanations or reasons behind the statistical results. Next, students' open-ended written responses to the question "What is the most significant thing you have learned at the end of the session?" were collected to evaluate how successful the instructional activities had been in conveying the value and attitude of the creative learning. This formative evaluation was especially helpful to encourage students to participate actively during the lecture.

Data analyses and Results

Next, six interviewees' transcripts were coding, comparing and summarizing according to the six factors that affected their attitudes and perceptions toward the instructional activities in order to get a richer sense of how role of affect during both the learning process of case study and the mind-mapping activity. In addition, the reflection generated by the interview data can add to our understanding of rewards inherent in students' learning and can provide information that suggests how the instructional activities might be made more enjoyable, meaningful, and productive.

The students' reactions, enjoyment and insights were presented as follows:

I. Cooperative Learning:

As team members brought different perspectives to the mind-mapping for their project, their discussion and debate advanced the project. During the discussion process, some students were willing to seek help from peers, and thereby learned valuable insights from one another. It was at this point that they started to focus on the improvement of their skills and learn from previous mistakes. Their enjoyment came from sharing the success of their intra-team achievements. For instance, although one student initially was confused by the opened-ended nature of divergent thinking, the process of interacting with peers led him to feel that he was very interested in and challenged by the demands of divergent thinking and eventually increased his potential to develop his problem-finding ability.

II. Participation of Teachers

During the interviews, students often mentioned that when the teacher conveyed and actively demonstrated how searching for the causes and effects of an unknown phenomenon would enrich their lives, they were very impressed by his sincerity and enthusiasm. Majority of the students expressed much gratitude for the teacher's support and involvement. As one student stated:

" The whole time we were there, he never said anything negative. It's amazing that he always had something positive to say. I think I've learned from him to be as creative as possible, always looking for new ideas, always challenging yourself to find something better."

During the problem-solving process, the teacher always encouraged these students to confront unfamiliar situations with courage and not to be afraid of making mistakes. The students have learned from the teacher to be proactive, to be curious about the source of problems, and to be confident enough to solve the problems in their own ways. Primarily First of all, the researcher classified interview data that were associated with six factors that was shown to be significantly related to creative learning for this group of students (see Table 1).

the teacher offered them encouragement and advice on how to cope with difficult situations. The students have gained many insightful advices from the teacher during the problem-solving process, and therefore the interaction between the teacher and students was no longer a source of anxiety and frustration.

III. Learning Outcome

After experiencing the mind mapping exercise, students indicated that they were eager to transfer the technique to other purposes, such as organizing their class notes or drafting how to construct a prototype airplane for the creativity contest. Even though a number of students commented that this activity left them confused as to what extent the mind-mapping exercise should come to an end, at least they have learned another thinking style, and which was the most rewarding experience for them.

IV. Classroom Atmosphere:

Some students felt that traditional engineering courses rely too heavily on theoretical, monotonous lecturing within the classroom environment and over-emphasize grades. In this course, however, they could express their creativity and imagination in a playful and non-judgmental environment. Students were in a collegial relationship with teachers, rather than being subordinates, enhancing the interaction between teachers and students. More importantly, it improved the teacher's rapport with students because the teacher knew on the spot whether the students were confused or interested in the concepts he demonstrated. In addition, students indicated that the non-judgmental atmosphere of this course made them feel safe to concentrate completely on the task at hand since both the classroom atmosphere and teacher-student interaction were more positive than other classes. One student indicated that it was during this class that he finally had the courage to express himself and not to worry about what others might be thinking of him:

"When I first start this class, I never had discussions with others. I've never had discussions with others. I've never asked them questions, either. Now I do a lot of discussions because in this class, it's O.K. to ask for help or to disagree with one another, even including teachers."

He also felt that these interactions motivated him to learn more and develop the confidence to pursue his own interests.

V. Comprehension of Instructional Activity

After experiencing the mind-mapping activity, they realized that if they did not consider the range of the project design more widely and prepare in advance for possible back-ups, problems may surface at later stages of the design process. That is the reason principles of mind-mapping were presented to help students link what they have learned to other courses, and then created a mind-mapping by connecting various domains of knowledge altogether. During the group mind-mapping process, one student claimed that all of his teammates were able to find ways to accomplish their goals by breaking down a formidable task into smaller, more manageable pieces. All these bits of information were important cures that they used to monitor the progress of their projects. In some situations where goals were not clearly set in advance, they were able to utilize the group mind-mapping to develop a strong personal sense of what they intended to do.

VI. Student Involvement

During the group mind-mapping experience, students have learned that the more they became involved, the more they saw the value of divergent thinking skill and were more willing to implement that skill to other domains of their lives such as preparing for their job searching or extra-curricula activities. In addition, they gradually developed their sense of responsibility and realized that each member's involvement and contribution was very crucial to the group as a whole. Evidently, it was found at the end of first semester that if the whole team did not have a mutual agreeable goal, it tended to drive the teammates away or have arguments with one another when the team was approaching deadline.

DISCUSSION AND CONCLUSION

The goal of the interdisciplinary approach in the creative mechanical design course was to integrate theories of creative problem solving with project-based curriculum for the benefits of engineering students. This course allowed students to experience first-hand the reality of applying creative and technical skills to the world outside the academic environment. Students were encouraged to learn how to solve a problem, how to synthesize various ideas of a problem, and how to communicate the results of their work to the class.

One bonus that comes from such a non-conventional approach to teaching that it was very enjoyable for the instructors as well as the students. Both teachers and students experienced a sense of achievement and confidence that increased their willingness to participate in this study and made them more willing to share their experiences. The discussions of their learning experience stimulated and allowed the participants to learn to reflect on the way in which they perceive the learning experience.

For the instructors, it was pleasing to see that students were able to find out what went wrong, and what could be done to correct the mistakes they were making in the learning process. For the students, the survey findings coincided with two major types of enjoyment which emerged from interview data: a) enjoying the experience of interacting with peers and the teachers, and b) enjoying the feeling that students have learned as a result of their own efforts.

In addition, the reflection generated by the interview data can add to our understanding of rewards inherent in students' learning and can provide information that suggests how the instructional activities might be made more enjoyable, meaningful, and productive. For instance, the degree to which interaction between teacher and students were shown to be instrumental in facilitatin learning of students in this course suggests that a collegial environment is essential for encouraging students to seek help from others and examine an issue from various perspectives. Despite the anxiety and insecurity they felt when first confronting the challenge of problem-finding, the mind-mapping activity offered the students a productive skill for responding to problems and thereby deciding on courses of action seen as possible and desirable. As they struggled to formulate and to understand their goals, creating a group mind-mapping offered an avenue for cultivating a better understanding of self and of others.

Future research as to how each of the factors contribute to creative learning might shed more light on ways to promote students' learning motivation and creativity. For instance, further research could be conducted to examine a possible association between classroom atmosphere and the potential for enhancing technological creativity of engineering students over the course of their learning to design. More work could also be done on the affective differences that express emotions, feelings or personal experiences between the learning process of instructional activities and the hands-on experience of project design.

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