Using Brainstorming and Appreciation of Novel Tech to Enhance Creativity in School Engineering Projects

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INTRODUCTION

Many studies consider creativity and innovation as essential drivers for students of all fields for solving social problems and creating social needs [1-3], especially in engineering education. In order to help establish a creative education system, changes need to be applied to the currently highly standardized education [1]. Firstly, teachers need to understand innovation so that they are able apply it to their classes [4]. Students of diverse groups should share knowledge and ideas with each other on the creative platform to successfully create innovative concepts [2]. Second,

innovative engineering education is not limited to classes. Badran [3] has mentioned that it should be encouraged for students to take part in extracurricular activities to be able to observe society inconveniences and conceptualize innovative ideas as a result.

This study hosts after-class reading clubs as a method to foster creativity. In this club, teachers can set additional time to invite experts to share new tech with the members. In addition, teachers with design backgrounds can guide students in brainstorming to develop design-thinking skills without affecting regular classes. It is discovered from the students' end-of-semester projects that besides choosing more diverse topics, the students are also much more concrete in expressing their created content through project mechanism and programing code design. Furthermore, diverse co-curricular stimuli assist in strengthening the students' initiative and creativity fostering. In conclusion, the students have shown significant improvement in creativity through their performance in engineering projects in their school's regular classes.

1 PRELIMINARY

Good education environments have been discovered to assist in inspiring and fostering creativity in students [5-8]. Firstly, creativity needs innovation teachers who understand innovation so that they are able to apply innovation to their classes [4]. Teachers have to act as mentors to properly guide and counsel students on the realization of their creative ideas. Furthermore, if available teaching assistants who understand innovation or have experience with creativity that help students make their creativity a reality, then the resulting effect is most definitely positive. Thirdly, during the developing of innovative thinking, interdisciplinary and intercultural students can help each other on the create platform to share knowledge and thoughts [2, 9]. When creative thinking takes form, the students' creative outcomes can be evaluated through practical means and project showcasing [10, 11]. As a result the students will be able to experience a more complete process of innovation. They can also learn how to transform creative ideas into real prototypes.

The planning and design of education content is also a key factor for engineering education. Bordogna et al. [1] proposed many academic/practical designs, teamwork, and problem discovering plus solving related directions to act as the core concept of the curriculum structure, and apply these directions to develop classes with potential to foster creativity. In the current planning of education, it is very difficult to integrate creative thinking or design elements into engineering education. The education system also needs to be well planned and designed in order to help plan a creative engineering education system [1, 3]. Therefore, existing engineering classes are all comprised of knowledge, skill, and attitude which are all factors for developing student competence [12].

Besides normal class education, students should also be encouraged to take part in co-curricular activities. Observing inconveniences in society through co-curricular activities can inspire innovative new ideas in students [3]. Additionally, getting to meet students from different cultures or departments, and as a result increasing creative diversity through interdisciplinary and intercultural groups is another benefit of co-curricular activities.

2 FOSTER CREATIVITY AND DESIGN THINKING

2.1 Brainstorming

Group brainstorming is a popular ideation method for design teams [13-15]. Advancing Inventive Creativity Through Education Workshop [11] advises using

visual thinking experiences to guide teams in brainstorming to inspire creative ideas. Also, Sibbet has proposed that when using visual methods to guide teams, three phenomena will be experienced: participation, big picture thinking, and group memory [16]. Firstly, when people participating in the discussion see their ideas being recorded, they will have a feeling of being listened to and accepted. After achieving this sense of participation, a group of people will be able to use big picture thinking. Through the use of message comparing, method discovery, and collaborated thought-blueprints, they become more intelligent. In the end, the visual method of discussion made it easier to remember things and greatly increased group memory.

The well-known design company IDEO have released the thinking-assisting tools IDEO Method Cards [17].Besides this, there are many different methods to transform imagination into creativity, each with their proper time and place, and their strengths and weaknesses. The most famous is the brainstorming method proposed by Osborne [18]. In practical use, the participants creatively think using a face-to-face method. Before starting, four basic rules will be explained. These four rules are designed to lessen peer pressure among participants and inspire design and imagination. Therefore, this paper will be reflecting on the outcomes for engineering students while brainstorming.

2.2 Appreciation of Novel Tech

As social needs constantly change, so too does technology constantly innovate. Students who are properly learning basics will also need to at the same time look to the future and accordingly take in the latest information. Badran mentioned that a good education system should be tightly tied to the industry [3]. Jørgensen and Andres proposed three different ways to apply innovation and entrepreneurship to the framework of engineering and design classes. Each one of these reflects a meaning of innovation and entrepreneurship [19]:

- The technology-driven conceptualization.
- The business selection conceptualization.
- The design intervention conceptualization.

Rump also explained these three points. Firstly, the engineering student learns skills and knowledge while undergoing basic scientific knowledge training. Secondly, the engineering student should build up business competencies. This is mostly related to business innovation and if they have the ability to become a start-up business man or woman. Thirdly, a new system will be designed under a growing society [8]. Regardless of whether or not the student is going to start a business, engineering, business, and design related innovative abilities are needed talents for the industry. To sum up, the methods to allow students to do some extent understanding and application of the latest knowledge, skills, market, and needs are very important. The aim of the appreciation of novel tech was to realize how the after-school club operated to promote the motivation and skills to enhance creativity in school engineering projects.

3 ENHANCE CREATIVITY IN SCHOOL ENGINEERING PROJECTS

Although adding creativity and design to Computer Science classes is good, the difficult part is the goal and easily attracts skepticism [20]. As science and technology continue to develop, people have constantly changing views and needs towards digital technological products. This has caused the career market to have an urgent need of people who possess knowledge in fields of both digital technology and

design. Therefore, Advancing Inventive Creativity Through Education Workshop suggested adding design-oriented classes to Computer Science classes [11].

3.1 School Engineering Projects

This study has chosen the 2nd year university class "Electronic Circuitry Experiments" to act as the study subjects. The students from the department of this study subject major in both computer science and design areas. The content of professional classes includes digital engineering and gaming/Internet multimedia. This class has a total of 18 weeks (Table 1). The students taking this class are comprised of 14 females and 27 males. Every student was asked to create a circuit as the mid-semester assignment. The students later divided into groups of 2-4 to complete an end-of-semester project. The students can freely decide their project topics.

Table 1. Electronic Circuitry Experiments Class Schedule

Week	Course Subject	Course Content	Experiment Content
1	Introduction	Arduino board& IDE	LED Blinking
2-6	Digital I/O Analog I/O	Basic Circuit	Using BTN to control SEVEN－SEG, LED GRID, Photoresistor Light Detection and adjustment, RGB LED
7	Capacitive	Capacitive sensing	Controlling LED with Capacitive sensing
	Mid-semester Project Explanation Announcement		
8-9	Sound& Motors	Buzzer, Step motor, Servo motor	Song playing, Motor operation
10	**Mid-semester Project Inspection**		
11	GIT Project	GIT Project Management	GIT operation
	End-of-semester Project Explanation Announcement		
12-14	PureData	Arduino Firmata	Using Arduino and PureData to mutually control each other
15	**End-of-semester Project Proposal (each team has 10min)**		
16	Other Interface	Infrared, Zig-Bee, Bluetooth	N/A
17	**End-of-semester Project Discussion**		
18	**End-of-semester Project Inspection(each team has 10min)**		

3.2 After-Class Reading Clubs

This study hosted four after-class reading clubs which were related to interactive design (Table 2) with one every week. Students who were taking the "Electronic Circuitry Experiments" class can freely join. Furthermore, these clubs were also open for other grades of students. The actual number of participants is a total of 37 people, which includes 17 students from "Electronic Circuitry Experiments" class. Every activity was divided into two parts with one hour each. The first part invited Human-Computer Interaction (HCI) related scholars and industry experts to share the newest studies and technological products. The second part invited professors with design backgrounds to help guide students in brainstorming. Brainstorming topics were different and so were the groups the students were divided into. The methods used for brainstorming were also diverse but all used post-it notes, pens, and posters to engage in a visual discussion.

Table 2. Reading Clubs Activity Content

Week	Appreciation of Novel Tech	Discussion Topics on Brainstorming
10	Wearable Interaction	Christmas Present Surprises
11	Interaction Design of Space	Integrating Sauces with Wearable Devices

12	Wearable Technology& Application	Problems in Everyday Life & How to Solve Them
13	Applications of Arduino	Reuse of Stationary

3.3 Assessment of Student Creativity

Creativity can come in many forms, such as the design, skills, or programming structure of a new mechanism. Therefore, more measurements of judging will be necessary for us to evaluate a student's creativity, and the student will need to receive praise from more fields. In this study, we applied the concepts of Torrance and Vygotsky to evaluate the student creativity.

The Torrance Test of Creative Thinking [21] splits creativity's evaluation fields into the following: (1) Originality: proposing unique ideas and full of creativity; (2) Fluency: well-flowing way of thought and can propose many practical methods; (3) Flexibility: can think very far and outside of the box; (4) Elaboration: precise analysis with lots of thinking and tries to go for perfection. On the other hand, Vygotsky's theoretical conceptions of imagination [22] states that creative activities are rooted in the brain's ability of combining elements. In addition, Vygotsky pointed out that imagination is dependent on a person's previous various experiences. These experiences provide the foundation for which imagination is built upon. The more abundant the experience, the better the association.

This study consulted the two above theories and re-established the methods.

- Concept Development: The richness of concept subjects.
- Fluency: The logical reasoning abilities based on the subject.
- Flexibility: The ability to manage information or objects as an individual.
- Originality: The ability to create unusual, brand-new, and unique ideas.
- Elaboration: The ability to breaks ideas down into details.

4 DISCUSSION

In regards to the students' end-of-semester project showcasing and the related creativity plus peer influence, it has been separated into three parts of assessments for discussion in this study: (1) Student Assessment: student questionnaire self-assessment and focus group interview results; (2) Expert Assessment: creativity assessment from academic and design-background industry experts' evaluations; (3) Teaching Assessment: interviews with the Electronic Circuitry Experiments class teacher and teaching assistant.

4.1 Student Self-Assessment and Focus Group Interviews

We asked the students to perform self-assessment via questionnaires and focus group interviews in regards to the creative achievements. Firstly, in the concept development phase, students thought wildly and stated that they were affected by their past experiences. Additionally, students would look up Arduino related works or videos on the Internet to get inspiration. After deciding their works' direction, students would theorize various different possible methods and propose some possibly viable methods. Secondly, in the actual production phase, the students mentioned that the most difficult problems all have to do with mechanism design. Neither classes nor the club offered related learning of skills of knowledge, so therefore the students had to use extra effort to surpass this. In this way, some students thought that their structures in the project were very creativity and were full of elaborate thoughts. To add to their project's uniqueness, they added mods or sensors that were not covered during the class onto their projects. Thirdly, in terms of peer influence, some groups would go have discussions with other groups and help each other solve problems

with their mechanisms or programing code design. Also they would take care not to make their own project too similar in topic or features. As a whole the students thought that the execution of creativity affected their work's completion. Furthermore, they proposed that realizing project creativity is a challenge that pushes them to work hard in learning.

Students who participated in the after-school reading club pointed out that the club helped them in numerous ways. For instant they have inspired their imagination regarding technology and that the club content had a positive effect on their end-of-semester projects. Even after the club event, participants continued to discuss and share with other classmates what they saw in the club. In addition, participants believed that in terms of the individual's learning and experience, the content of the club had greatly broadened their horizons and had a very positive effect as a whole.

4.2 Evaluation from Academic and Industry Experts

This study invited two researchers from related academic fields and two designers with veteran design experiences to perform expert creative evaluation. Experts were asked to evaluate the creativity of projects developed by the two classes of students. These two classes have the exact same class schedule. The only difference is that one did not host any extra after-class reading clubs. The results show that four experts unanimously agree that the class with club was superior to the other class in all this study's fields of concept development, flexibility, originality, and elaboration. The experts' consensus is as follows:

- Diverse co-curricular stimuli assist in creativity fostering.
- Students of the class with club have more creativity that allows for new forms of structures to appear.

In terms of fluency, the academic experts thought that based off of the logical reasoning ability created from the topic, the two classes were not significantly different. On the other hand, the industry experts thought that in terms of topic choosing that although the class with club has more creative ideas, it is still recommended for the students join a public topic and conceptualize ideas through solving everyday problems. This will help their projects become more thematic.

4.3 Evaluation from Class Teacher and Teaching Assistant

The teacher stated that project topics of the class with club were more diverse and cover many different areas. However, most students of the class without club mainly developed music related interactive devices. During production, the students of the class with club were more actively. They asked questions and discussed with the teaching assistant frequently about the viability of their end-of-semester projects. As a result of the creative education, both the teacher and teaching assistant agreed that not only do the students of the class with club have better creativity, and they also are much braver in facing the difficulties that face them when executing creativity.

5 SUMMARY

Under the condition that the regular classes are not affected, hosting after-class reading clubs with voluntary participation can strengthen the students' creative abilities in school projects as well as enriching the variety of their projects topics. It was found in this study that tech appreciation and brainstorming activities had a significant effect in strengthening the student's ability of conceptualizing their projects.

Students are also much more concrete in expressing their creation content through project mechanism and programing code design. Students have also noted that making their creativity a reality was a challenging task. As long as there were a certain number of students from the class participating in the reading club there would be influence from peers. Furthermore, diverse co-curricular stimuli assist in students' initiative and creativity fostering. In conclusion, the students have shown significant improvement in creativity through their performance in engineering projects in their school's regular classes.

In the future we will try and integrate ways to develop creativity along with regular classes. In the beginning of every class experiment we will try to add tech appreciation of related content. At the end of the end-of-semester project proposals we will try adding brainstorming activities. These are all to study how to develop creativity in regular classes.

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