AN ANALYSIS ON THE TEACHING PROCESS OF CAPSTONE COURSES -TAKING THE BEST AWARD OF NATIONAL COLLEGES' PRACTICAL PROJECT COMPETITION AS AN EXAMPLE

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Abstract-This research was focus on the teacher who has led students to winning prized topics in the National Colleges' Practical Project Competition (NCPPC) and his capstonecourse (practical project) teaching experience in electrical engineering and computer science department in technological university. After reviewed related literature, we set our interview course according to scholar Shyu's idea of the five stages of inducting teaching process in project-based learning (PjBL) courses. Semi structured interviews was used on the top three prized project advisers of the NCPPC of year 2014, 2015 and 2016. We collected the data of teaching process of project courses, and after data coding and analyzing the transcripts. The findings of this research were concluded as follows: 1. Electrical engineering teachers in technology universities have five stages during their teaching: Preparation, Implementation, Presentation, Evaluation and Revision. 2.During each stage the teacher will emphasize on enhancing a different technique of students, in preparation stage will work on professional techniques, in Implementation stage will lead students to data collection, during presentation stage students have a chance to improve oral speaking, evaluation stage helps with multi-evaluation, and revision stage helps student learn about applying for patents, And 3.Electronical engineering field students in technology universities will gain their knowledge during preparation stage, in implementation stage they get to learn about team spirit, the presentation stage enhances their vision and technique exchanges, the evaluation stage they get to accept and hear different advices, and the revision stage they will then participate in competitions and make improvements.

Keywords: Project-Based Learning (PjBL), Capstone Course, Project Courses, Teaching Process, National Colleges' Practical Project Competition (NCPPC)

I. INTRODUCTION

Taiwan's IT industry has come a long way to today, and thanks to the high-density promotion of the industry, the sector has become a vital component in the global supply chain. In 2014, Taiwan's IT industry accounted for 40% of the nation's total export and 15% of Taiwan's GDP for the year [1]. With an annual export growth rate of 10.24%, IT products have been the main form of merchandise that Taiwan exports to the rest of the world. Taiwan's overall annual production growth rate is 6.86% and IT parts alone grew by an impressive 17.15%. Not only that, other related products such as machinery equipment and PC electronic products have also emerged as the primary driving force leading growth for Taiwan's manufacturing industries. These figures reflect the importance of the IT industry to Taiwan [2].

Looking back at the history of education development in Taiwan, technological and vocational education have played a significant role in facilitating Taiwan's economic growth and enhancing the nation's industrial development in the past. However, considering the existing demand from the domestic sector for talent, due to the inadequacy in practical training offered by schools, we now have a short supply of talent to accommodate the actual demands of the industry due to industry-academia discrepancies [3]. In order to create more opportunities for students to have more practical training, one way to ensure optimal industry-academia connection would be to have various faculties and departments in domestic colleges offer capstone courses as a focal point of academic affairs promotion [4]. Incidentally, the Ministry of Education stated that through NCPPC, schools will be able to offer more accurate guidance for students to have a better grasp of the current situation in the domestic industries and thereby close the gap between their learning and application of skills. In an effort to help students boost their practical skills, instructors at various university of technology have actively encouraged their students to participate in the NCPPC [5].

Having established the aforementioned facts, the purpose of this research is to explore the key factors in the teaching process adopted by instructors who have led students to win prized topics in the NCPPC when they teach practical project courses at university of technology; the conclusions and suggestions towards the end of this research shall serve as a reference for electrical engineering and computer science departments at university of technology looking to improve their practical project courses in the future.

II. LITERATURE REVIEW

A. Current Status of the National Colleges' Practical Project Competition (NCPPC)

Starting from 2002, the Ministry of Education has organized the NCPPC on a yearly basis and the event has been an indicative national competition for students across technological colleges and universities

in Taiwan. Taking 2017 as an example, the organizer received a total of 1518 entry submissions, which were referred to dozens of experts in accordance with their categories for preliminary review of the written proposals. 143 practical projects made it to the final round of the competition and the top three projects along with a number of honorable mentions were chosen to be the winning entries. The goal of the NCPPC is to help students learn more about the practical work that is being conducted in the industry and the dynamics of the industry and the market through competition, thereby facilitating the results of applying what they have learned to their future line of work [5].

B. *Implication of Capstone Courses at University of Technology*

The fundamental intention behind the practical project courses offered at various technological colleges is to help students boost their capacity for practical work and self-training and enable them to be exposed to the industry preemptively so they can see for themselves the current status of practical work in the industry. This is implemented by dividing students into groups and asking them to complete a research project prior to their graduation [6]. At present, technological colleges have offered practical project courses that enable students to work in teams while combining theoretical knowledge with practical work as they experience the process of problem-solving in the real world. During the learning process, students are able to transform from passive receivers of knowledge into active explorers and in turn construct their knowledge process [7].

C. *Implication of Project-based Learning (PjBL)*

In the early 20th Century, American educator W. H. Kilpatrick proposed a specific approach to teaching and learning based on projects: hence the approach is known as Project-Based Learning. The approach advocates that education offered in schools ought to be oriented towards projects that students have chosen and those that facilitate "activities with purpose". Not only that, instructors should focus on guiding students in problem-solving for various applications in their teaching and allow students to choose projects based on their actual objectives in order to achieve the goal of learning[8]. Project-based learning has already been adopted by many in local and foreign education circles, and several scholars have explored theories of project-based learning and developed teaching models for project-based learning. For example, Shyu, Hsin-yih proposed five steps of implementation (abbreviated as PIPER) in her research: 1.Preparation: verify the scope of topic, determine the teaching objective, confirm the schedule of progress and method of evaluation, confirm resources, verify prior knowledge, organization/team and instructor training; 2.Implementation: arrange and define the division of labor and responsibilities, brainstorming, formulate the plan for projects, propose hypotheses, collect relevant data, analyze and authenticate relevant data, team collaboration, progress report, integration of results from analyses and propose conclusion; 3.Presentation: present and share the conclusions and findings from the study (in the format of a written report and oral presentation); 4.Evaluation: assessment of project-based learning results with self-evaluation, peer evaluation and expert evaluation; 5.Revision: revise the project based on the results of evaluation to finalize the project and complete the learning process for the project [9]. For the purpose of this study, Shyu's five stages of project-based learning implementation include: preparatory stage (P), implementation stage (I), presentation stage (P), evaluation stage (E) and revision stage (R) shed light on the teaching process for instructors.

D. *Related Studies on Project-based Learning*

Project-based learning has already been applied in education at different stages, levels (spanning pre-school learning to higher education) and backgrounds in the past [10]. To begin, a Swedish study on preschool science teachers suggested that the project-based learning model offers the potential to facilitate preschool science education [11]. U.S. research that explored social studies and content literacy for grade two students taught with the project-based learning approach pointed out that project-based learning is beneficial in closing the gap between students from low income families and those from families of a higher social/economic status [12]. With regards to junior-high school education, many studies have found that using project-based learning or technological project-based learning could help to improve junior-high school students' higher order thinking, learning motivation and attitude, thereby helping them to attain significantly higher test scores compared to those in the control group [13][14][15]. Finally, at the level of higher education, a group of Portuguese undergraduate students participated in project-based learning and the research found project-based learning to be effective in enhancing students' motivation for learning and improving their participation in the course [16]; another U.S. study on a bioengineering course also discovered that students in a project-based learning course show significant improvement in their capacities for problem-solving, written communication and self-oriented learning [17].

III. METHOD

For this research, interviews were carried out with Chang J. C. [18], the principal investigator of the MOST research project "The innovative instruction for engineering and design curriculum: Innovative products embedded teaching methods for senior project" in order for the interview data to be sorted and analyzed. Purposive sampling was chosen as the means of research subject selection in order for suitable subjects to be chosen in accordance with the objectives of this study. There were three criteria for

sample selection: (1) subjects must be involved in the 24 winning entries in the NCPPC between 2014 and 2016; (2) instructors who have previously taught practical training courses at electrical engineering and computer science departments in university of technology; (3) instructors who are highly passionate about practical project courses and willing to share their experiences and personal perspectives. With these criteria in place, invitations for interview were sent to instructors at 13 schools. Among the 13 schools, 7 schools responded to the invitation and due to specific complications for some interviewees, in-depth interviews were conducted with instructors from 5 schools. The list of interviewees is shown in Table 1 below.

Table 1 List of Interviewees

Award-winning Categories	Year	Placement	Date of Interview
Electrical Engineering	2015	1st place	2016/11/10
	2015	3rd place	2016/12/08
	2014	1st place	2016/11/22
Computer Science &Telecommunication	2016	2nd place	2016/11/09

In this research, open coding was chosen to process the interview transcripts as suggested in the Grounding Theory proposed by Strauss and Corbin [19] in order to conceptualize and categorize the interview data. This enabled further classification of primary categories for further development based on the aspects of different attributes to derive secondary categories. The transcripts were then processed with axial coding to identify the correlation between primary categories and secondary categories and finally selective coding to integrate and refine the theory by creating a core concept and building a complete theoretical structure on top of it. Throughout the coding process for data analytics, the three coding approaches enabled conceptualization by means of induction and deduction to identify the core scope that led to the construction of the theoretical framework.

IV. RESULTS & DISCUSSION

E. Practical Project Courses Arrangement at the Preparatory Stage

The study found that at the preparatory stage, capstone courses offered by electrical engineering and computer science departments in university of technology would be arranged for junior students in the second semester and senior students in their first semester. In order to help students hone their professional skills, some instructors would actually allow students to start their learning early in the laboratories so that they could build upon their prior knowledge through guidance from their seniors and relevant prerequisite courses. By focusing on specific elements from day-to-day life and extensions of entries from previous years, students and instructors could develop suitable topics for research and by involving instructors, students and the sector to come up with topics, the process could inspire more creative ideas that they might not have thought of. However, relevant studies have shown that project participants demonstrate higher capacities for exploration with research topics that stem from student group discussions. Students are more inclined to invest more effort to see their project carried out till the very end and truly comprehend the content of their research for topics that came as the result of group discussion due to having a common objective [18].

F. Practical Project Courses Execution at the Implementation Stage

The study found that at the implementation stage, instructors from electrical engineering and computer science departments in university of technology would not restrict the number of members in a team but instead would allow students to form their own groups based on their own learning preferences. The majority of groups were made up of four members and students could divide and allocate tasks and responsibilities (i.e. software, hardware, network and so forth) based on factors such as personal experience, hobbies or expertise so that they could utilize tools or techniques they were proficient in to complete the project. During the course of their projects, students would find themselves needing a substantial amount of budget and their instructors would evaluate their projects and needs and apply for a subsidy from the school. On the other hand, instructors are required to intervene in group discussions at the appropriate moment to offer professional competence and technical guidance to help students in the process of data collection from technical databases, the internet or relevant publications so that students can accumulate hands-on experience and perform various tests and adjustments on their projects to create learning effects that are profound and lasting [20].

From the interviews, the researcher became aware that in the Capstone courses, instructors would inevitably run into many situations. For example, students' professional competence and status of learning might be below the instructor's expectations/anticipation and when this happens, the instructor could only seek to boost the student's rudimentary competence through basic training and exercise and adjust the difficulty of the given problem when it was deemed necessary. Students would sometimes have trouble with the division of labor in their team work and instructors would encourage students to express themselves and seek the best solution through group discussion to train their capacity for communication and expression.

G. Presentation of Project at the Presentation Stage

The study found that at the presentation stage, electrical engineering and computer science departments/schools in university of technology would schedule the project presentation at the end of the students' second semester. At the presentation, each group of students would be required to give an

oral presentation and demonstration of their project. In the process of presenting their projects, students would be able to apply the professional knowledge they acquired in practical applications, thereby stimulating their creativity while training their capacity to express themselves, communicate and integrate their knowledge for application. Not only that, by being exposed to other teams' projects, they would be able to learn about the strengths of other teams and reflect upon their own shortcomings. This would help them to broaden their vision and pick up different knowledge from other teams to in turn facilitate technical exchanges among students.

H. Method of Project Evaluation at the Evaluation Stage

Instructors from electrical engineering and computer science departments in university of technology would take the project presentation as their primary means of evaluation at the evaluation stage. Through the rating of different projects at the presentation and assignment of scores from instructors for proportion calculation, students would be able to raise questions from different perspectives among peers and work to resolve issues in meetings. Through peer evaluation, the process could stimulate creative thinking without restrictions and lead to more creative ideas that are beneficial to the improvement of students' learning capacities. In the "VTE Reconstruction Program" implemented by the Ministry of Education, "introducing resources from the sector to assist in the teaching process" has been identified as the approach to select and hire instructors from the industry to take part in the course design and teaching process along with schools in order to ensure a seamless bridge between the courses offered by technological colleges and the industries in the hopes that instructors with backgrounds in the industry could assist in the teaching process to boost other instructor and students' capacity for practical applications to highlight the features of vocational and technological education while further facilitating industry-academia exchange and collaboration to achieve win-win and mutual benefits [21]. While most of the interviewees pointed out that their schools did invite experts from the industry to evaluate students' projects at their presentations, some university of technology still failed to comply by hiring instructors from the industry to offer their guidance and evaluation. As such, university of technology is recommended to make improvements in this aspect in the near future in order to truly ensure that their students are adequately prepared for the industry.

I. Learning Process after Project Completion at the Revision Stage

After helping their students to complete and revise their projects for their presentation, instructors from electrical engineering and computer science departments in university of technology would actively encourage their students to take part in various competitions outside of their schools (mostly events hosted by the Ministry of Education and relevant companies in the sector). Taking part in competitions organized by the Ministry of Education and achieving a good performance would help students in their future academic careers; while helping students to compete and win in events hosted by corporations would help the corporations to take note of students' talents and help the students become connected to the businesses to close the gap between their learning and application of skills.

As the interviewees pointed out, award-winning projects would go through relevant improvement after relevant experts shed light on specific market demands to ensure that these projects would become compliant in their corresponding fields of application before the projects are patented and converted into physical products. As for the students, due to their involvement in the practical project courses, they would receive invaluable practical and learning experiences from the process of their participation and perhaps discover their interests and continue to work hard in relevant fields while pursuing their different goals of completing their education, seeking employment or starting their own businesses to truly attain the greatest benefit of practical project courses.

CONCLUSIONS & SUGGESTIONS

J. CONCLUSIONS

1) Electrical engineering teachers in technology universities have five stages during their teaching in Capstone course: Preparation, Implementation, Presentation, Evaluation and Revision.

With regards to the teaching process for instructors of practical project courses from electrical engineering and computer science departments in university of technology, the study has found that students' training prior to their participation in the NCPPC to be vitally important. At the preparatory stage, students need to go through preparations of professional skills and knowledge; at the implementation stage, instructors are required to guide their students through extensive data collection and resource acquisition before students divide their responsibilities in teams and collaborate to complete their projects; at the presentation stage where schools host their project presentation, students are required to make adequate use of their capacity for expression and communication to present the results of their projects; at the evaluation stage, students' projects would be subjected for evaluation by their instructors, experts from the industry and peers to inspire different creative thinking; finally at the revision stage, instructors would guide their students through the process of revision for the finalized project based on various suggestions before students are officially entered into competitions and patent application to complete their practical project courses.

2) During each stage the teacher will emphasize on enhancing a different technique of students, in

preparation stage will work on professional techniques, in Implementation stage will lead students to data collection, during presentation stage students have a chance to improve oral speaking, evaluation stage helps with multi-evaluation, and revision stage helps student learn about applying for patents.

First and foremost, instructors are required to have a solid grasp on the professional core capacities and techniques that are required for a practical project course. Instructors are responsible for planning a series of professional courses that span four years to help students build upon their fundamental competence for practical project creation so as to cultivate future talents for new technology and innovative development for the IT industry. On the other hand, with regards to the arrangement of courses, schools could enable students to choose their preferred instructor in advance in order to have early access to laboratories to learn various professional techniques and practical work so as to enhance their competence through experience and ultimately bring their practical project to a higher level.

The study has found that students are capable of using relevant technical databases to rapidly find the tools they need to facilitate the progression of their practical projects. Not only that, they would resort to the internet or relevant publications to gather more useful literature while receiving guidance from their seniors and sharing what they have learned to achieve knowledge sharing, imparting of knowledge and passing down of know-how to future generations of students. During the course of the practical project presentation, in addition to relentlessly boosting students fundamental knowledge and techniques, instructors would also be training their students' oral presentation skills through a series of drills and reports so that students would be able to fully present and highlight the features of their creative endeavor. As for instructors, they ought to arrange for different models of evaluation and utilize diverse evaluations by instructors, experts from the industry and peers to inspire ideas from different perspectives in order to revise students' projects based on valuable input from various parties and guide students through the process of patent application. This would inspire students' motivation for entrepreneurship and continue their development in relevant fields and the instructor would be able to grow together with the students during the process of practical project guidance.

3) Electronical engineering field students in technology universities will gain their knowledge during preparation stage, in implementation stage they get to learn about team spirit, the presentation stage enhances their vision and technique exchanges, the evaluation stage they get to accept and hear different advices, and the revision stage they will then participate in competitions and make improvements.

For the students, in order for them to understand that they need to apply what they learn in their practical project courses, it is imperative for them to find the field of specialization that they are suited for as early as possible. Starting from their acquisition of knowledge by taking a series of courses offered at their schools, students would accumulate some of the prior knowledge that is needed for specific practical project courses. Students would then brainstorm on the type of suitable research topics from their day-to-day lives or seek inspiration from award-winning entries from the past with the guidance of their instructors. Through the process of constantly thinking about ideas, students would unknowingly learn and grow. Alternatively, they could also find topics that they might be interested in from the industry and this could help students to become connected to the industry early and learn about the current status of their field of employment in the near future. As each group would comprise members of different specializations, effective division of labor and team work would facilitate the process of practical project production. Different aspects such as hardware, software, network, communication and so forth would require students to be proficient and students could utilize different channels for learning and collecting data before they share their learning and experience with one another. The effects of peer learning among students are beneficial to achieving greater learning results when students demonstrate true team work and collaboration. At the project presentation stage, students would be able to broaden their vision and take part in technical exchanges at different presentation venues to further inspire more creative thinking; after they have completed their on-campus practical project presentation, students will revise their projects based on expert suggestions before submitting their projects as entries in different competitions and continuing to improve upon their projects for patent application. During each of the aforementioned processes, students need to collaborate and work with their instructors and team members in order to earn recognition and achieve their desired results.

K. LIMITATIONS & SUGGESTIONS

1) Suggestions for Electrical Engineering and Computer Science Departments in Technological Universities

Practical project courses offered at university of technology are a capstone that is different from conventional academic courses. Throughout the entire teaching process, instructors in a practical project courses are required to invest a substantial amount of time before their students can complete a project of outstanding quality. As such, the study would suggest that schools schedule their practical project courses during the second semester for junior students or the first semester for senior students and allow students to choose their instructors early so that they could gain access to laboratories and receive guidance from their instructors and seniors to further boost their professional skills and capacities. The study also

suggests that schools establish specific procedures governing subsidies for practical projects to enable students to submit proposals so that students can be reimbursed for actual expenses in their projects. In addition, schools should also establish relevant procedures for off-campus competitions to encourage students to actively take part in competitions held outside the school by offering scholarships as an incentive for students who create prize-winning projects. This would encourage students to be more motivated in their learning as they endeavor to bring honor to their schools.

2) Suggestions for Instructors in Electrical Engineering and Computer Science Departments in Technological Universities

In their study, Yeh, Lin, & Chung [22] pointed out that domestic technological colleges and universities place a heavy emphasis on practical studies and industry-academia exchanges, and as such, most schools would offer practical project courses in the hopes of facilitating topical studies that could integrate instructors, students and practical work in the industries. As such, the study suggests that instructors in electrical engineering and computer science departments in university of technology ought to strive to seek assistance in teaching from instructors with a background in the industry to help students become more professional in their practical project creation. Through the incorporation of field experience from the industry, instructors will be able to further boost their professional knowledge. With regards to brainstorming for potential topics for practical projects, instructors should attempt to help students to have a personal appreciation for the topic through relevant elements in their day-to-day lives to stimulate their motivation for learning and use the capstone as a means to take students beyond the confines of their schools into the real market (i.e. communities, stores and so forth) so that students can see for themselves and discover the market demand before they apply the knowledge they have learned to resolve the problem in the market. This would help students to train their capacity to identify opportunities and problem-solving abilities [23].

3) Suggestions for Students in Electrical Engineering and Computer Science Departments in Technological Universities

From the interviews, the study has found that most of the teams that have delivered award-winning entries in the NCPPC consisted of four members. As such, the study suggests that students taking practical project courses should be divided into groups of four based on their strengths and expertise to work as a team on their project production. Through means of community service, students will be able to gain a solid understanding of communities' actual needs so that they could work on topics that relate to community needs to facilitate collaborative problem solving. When students integrate their research topic with learning through service, they would be more inspired to activate their potential for cognition, social interaction and moral standards [24].

4) Suggestions for Follow-up Studies

For this study, a qualitative research has been chosen along with semi-structured interviews as the primary methodology. Since the conclusion from this study only covered the successful experience and teaching process from five interviewees, the study suggests that researchers gather both qualitative and quantitative data through field observation or action research to ensure greater reference values for their study as it would offer a more comprehensive insight into the teaching process adopted by instructors from electrical engineering and computer science departments teaching practical project courses in university of technology.

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