Design and Development of an Innovation Product Engineering Process Curriculum at Peking University

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Abstract Over the past decade, the elements of innovative wisdom are not only a business organization to survive in the dangerous environment, school organizations to enhance the quality of education to meet the needs of the community. For the succession challenge in the continuous impact, an innovation level of a top university covered the administration, curriculum, teaching, equipment, environment and so on is quite extensive. This paper overviews a novel curriculum at Peking University, called Innovation Product Engineering Process, established by six interdisciplinary teachers for school students in various professional fields. The curriculum aims at inspiring students to break through professional limitations for experiencing the innovation process from idea into product. The students are self-organized as a team and construct a prototype collaboratively. Instructors from industrial give a practical perspective lesson and provide market information, funding and technical support. Students in the course are fostered six expected abilities, including creativity, practical, engineering process, team-working, communication and expressiveness. Ideas from students become the topic of a project after competing in three eliminating rounds. All competitions are graded and ranked by the participators (teachers, students, instructors from academic and

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industry). Finally, six ideas having the opportunity to become prototypes are developed successfully with various properties. Most of students indicated that the curriculum provided them a new training experience, interesting learning style and useful content of courses.

Keywords Workforce development · Product engineering process · Course development

Introduction

Cultivating and training innovative talents is certainly important in order to building an innovative country and improving international competitiveness. School students having high social resilience and entrepreneurial capacity is one of the aims of the long-term education reformation and development program from 2010 to 2020 in China. It should be achieved through education and training of various fundamental science, research and practice. High level education in engineering, besides, in China mainly fosters people translating science and technology knowledge into productive power [1]. Developing students' innovation through engineering practice, integrating technology, humanities, economics and management knowledge, is also an important part of advance engineering education. The interdisciplinary cooperation, however, is few and far not only between academics but also between colleges and enterprises. Advance engineering education, therefore, should be oriented strenuously towards the practice of engineering process. The integrated engineering activities training a student solving complex, comprehensive and interdisciplinary problem collaboratively with different professionals have become the key point of education around the world.

Currently, the reformation of engineering practice is initialed in US and few academics have set up the courses for inspiring students in product processing engineering. The Conceive Design Implement Operate (CDIO) project [2] in Massachusetts Institute of Technology is regarded as the representative in this teaching model and its teaching manner provides students to experience a life cycle of a product process in the real environment. Project-based learning (PBL) in engineering practice is adopted in Canada [3]. Students as a team to completing the production of the specified projects put the theories and methods what they have learned in use. Different from the traditional curriculum, learning assessment is not only dominated teachers but taking a combination of student self-evaluation and peer evaluation by team members. Evaluation system and the way of the reformation of engineering practice courses, as a result, is an advisable merit of the PBL. The reformation in British perform practice course intending to improve the learning experiences of the science and engineering student to be "engineer" instead of "student." Furthermore, the engineers in industry are invited to give

lectures or workshops for importing working experiences and instructing interdisciplinary exercises. Academics also connect a two-way interaction with industries in order to understand the demand for graduates. The courses recently increase the number of knowledge in humanities, economics and social sciences [4].

In recent years, the reformation of engineering education and practice are speeded up in China, and a lot of improvements on student participation and engineering practice are achieved. Comparing with the developed countries, however, two problems as follows are still critical. (1) The course of engineering and practice mostly focus on technical contents without much attention on general educations. (2) Teaching proportion of the arrangement in a course is unreasonable and the importance of a teacher in engineering practice education is over-valued. Consequently, students emphasize technical tools and skills too much during their learning in education. Self-innovation of students is probably disappeared under the situation of education. In order to increase the creativity and innovation of students at Peking University, the co-authors from different fields open a novel and interesting course with the following originality in China.

- Inviting engineers and managers from industry to sharing market information, providing finance, importing experiences and so on.
- Providing comprehensive knowledge including social science, engineering and management to students.
- Fostering students to experience product engineering process through completing a project.
- Allowing students to participate in the evaluation system of the course and scoring an idea or a work with the "press" equipment.

According to the outcome of the course and feedback from students, well interaction among teachers and students is observed, and curiosity about engineering and practice capability of students are improved. Students also understand and respect the opinions and works of others. School members comprehend the needs of industries and the discipline of the projects includes chemistry, computer science, communication, signal processing, the design of application on tablet PC or smart phone and so on. At the end of lesson, a company in China even intends to invest its resource in one of them as a product in the future.

Course Description

The course being team taught by the co-authors of this paper and titled, "Innovation Product Engineering Process," at Peking University has the following purposes in creating this course:

- Design a course integrating topics from interdisciplinary content relevant to product engineering process.

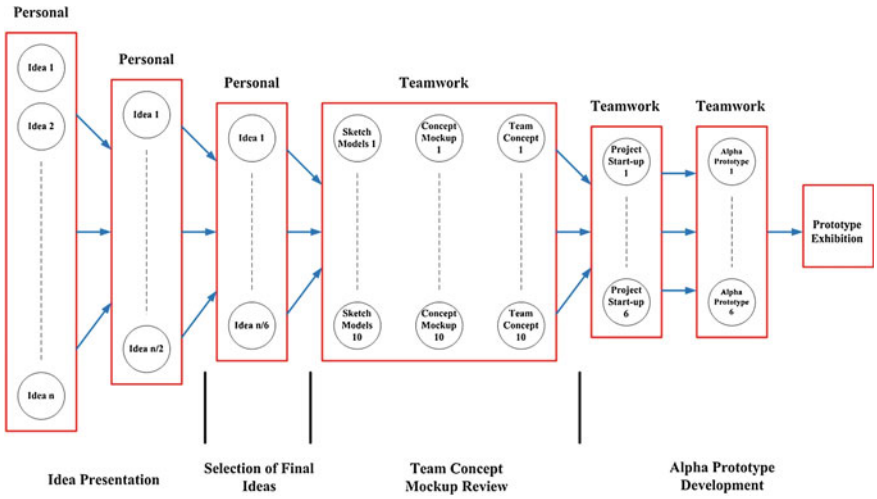

Fig. 1 A high-level schematic of the project workflow in the course is delineated

- Design a course to target audience of undergraduate students of various professional fields.
- Design a course with a teaching team including members in academics and industries.
- Design a course to provide students funding and technical supports to experience from idea creation to prototype making collaboratively.
- Design an evaluation system to allow students participating in.

A high-level schematic of the project workflow is shown in Fig. 1. The process leading to a functional and workable prototype is separated into four major milestones: the ideas presentation; selection of final ideas; team concept mockup review; and prototype development. Every student, at first, in the course creates more than an idea, and these initial ideas are examined in three eliminated round. In the stage, ideas are made under students' brain storming, surveying literature and sharing information. Ten initial ideas then become the major topics of a team project—they work in full cooperation and virtually coordinating resource as appropriate before team concept mockup review. The goal of the team concept mockup review is to inform instructors about the state of the project's functional, the concept of final prototype. This feedback also provides each responsible team prioritize improvements for the final presentation. Course content coverage is described as follows:

- Ideas Presentation
  - Week 1: Overview and introduction to innovation, creativity and entrepreneurship [Lecture].

  - Week 2: All students share personal ideas as more as possible and make a defense to others' interrogation. Here 50 % of the ideas are eliminated.
  - Week 3: Research and design process in an innovated project. [Lecture]
  - Week 4: The students survived in the last competition represent the selected idea in 3 min specifically and also make a defense to others' interrogation. Here 30 % of ideas are collected to next eliminating rounds.
- Selection of Final Ideas
  - Week 5: Fundamentals of proposal writing, and how to make a business plan. [Lecture].
  - Week 6: Each one of the remainder ideas should be represented clearly and specifically in 10 min, including requirement, application and scenario. The students initiated these ideas make a defense to others' interrogation and only ten ideas are selected.
  - Week 7: A special workshop is hold in the class for interaction freely among the original designer and other classmates, and then making a team finally. The designer with his team members, moreover, develops sketch, technical drawing and preliminary plan of the idea as a project.
  - Week 8: Each team has 15 min to make a detail presentation on their preliminary project, and the responses to others' interrogation are also considered. In the end, only six teams are obtained the opportunity to implement their idea with all supports, such as finance, technical, laboratory. Besides, a school teacher is responsible for technical advising, trouble shooting and schedule control of a team selected. Each team also has a budget of near ¥ 3,000, depending on the discussion of all school teachers, to purchase materials, supplies, and resources for the project. The members of the eliminated teams are separated themselves into the succeed teams.
- Team Concept Mockup Review
  - Week 9: The relation between technology and product: why failed? [Lecture].
  - Week 10: A discussion is hold for interaction, exchange and information sharing among all members in the class.
  - Week 11: Management and control of a project. [Lecture].
  - Week 12: A discussion is hold for interaction, exchange and information sharing among all members in the class.
  - Week 13: Leadership, communication and exchange. [Lecture].
- Alpha Prototype Development
  - Week 14: Each team must plan and work to keep their projects on budget and on scheduled. Moreover, they have to report their progress, balance of appropriations and technical detail. The teachers consider budget extensions while a budget overrun for further completing the project well is required.
  - Week 15–18: Each team keeps doing their project and reports to responsible school guidance. Furthermore, a few lectures and discussions of which the speakers are invited from enterprise or industry are held from time to time.

– Week 19: A whole-school exhibition is held for final presentation made by the team's representative and the demonstration of its alpha prototype in interesting, funny, formal or surprising way is necessary.

The lectures with different topics are given by different professional co-authors, engineers, and managers from industry. This course was offered for the first time in spring 2013 and met class once a week with each lecture and workshop being approximately 180-mins. Student's feedback and evaluation of course will be taken into account to improve the course contents and organization in future offerings. Students' performance on idea propagation, teamwork performance, system design, and final presentation is considered as the measure of this course.

Project Budget

Most of financial support in the course is provided by Peking University. In the stage of selection of final ideas, the teachers determine the practical financial needs according to the proposal, scheduling, scenario and development requirements. The final budget of a team is accepted with over 50 % guidance's agreements. On average, each team has a budget of ¥ 3,000 to purchase materials, supplies, and resources for the project. Each team member must participate in planning and keeping their projects on budget and on scheduled. The project budget is not compliant after verdict in the class. The teachers, however, consider budget extensions of a project while a budget overrun for further completion is required. There is only a chance to add their budget up while reviewing the mockup of team concept. Each team member will pay an equal portion of deficit if their budget is overrun. Moreover, each team is allowed to have sponsorship fee from enterprises.

Grading

The overall score of a student is graded based on four parts with its proportion: idea propagation (25 %), teamwork performance (25 %), system design (40 %), final presentation (10 %). Before forming a team, the performance of a student is evaluated as a partial personal grade. All members including teachers and students in the course vote pass or fail to the idea into next eliminated round, and the assistant instructor calculates its score. Here customer needs, thoughtfulness, clarity and quality of the design alternative of the ideas are considered. Once the six ideas are determined as the major content of a team, personal score of a student is graded in the "idea propagation" part. After that, the review contributes to a portion of a shared team-wide grade and members of course or team participate in the rest review process. Key grading critical in teamwork performance are operating, activity, workload and communication in coordination. The score of a

student in this part is graded by all team members and guidance. Furthermore, all members in the course participate in grading a team in system design, of which key critical contains mechanical design details, system integration, details of prototype execution and manufacturing. In the final presentation, it takes place in one day of the summer vacation and provides each team with the opportunity to show their works to various audience including academics and industrial visitors. All participators in the exhibition evaluate a team's work based on team's performance in customer data, market information, specifications, or benchmarks for the product.

Prototype Exhibition

The final milestone in the course is a formal presentation which is attended by the overall members in the course, all guidance, sponsors, and guests from academic and industry. A portion of the shared team-wide grade is contributed in the exhibition. Each team has the opportunity to demonstrate their work to all participators. Students may learn how to prepare a complete technical presentation in a life-styled, educated, technical, or business oriented way. A team is also allowed to seek investors for their product to start-up a company. Each team is evaluated and graded by all participators based on its presentation quality, business assessment; technology, the prototype, and overall potential to become a real product.

Summary

A new curriculum combining innovation, learning, co-operation and practice is in development at Peking University in line with the need of interdisciplinary training to product engineering process. This course covers creativity, teamwork, management and practice of a project realization emphasizing pioneering aspects. After taking this course, students are expected to contribute to the start-up aspect of industrial projects related to product engineering. Students will be able to understand vulnerabilities and difficulties to the product engineering process in addition to realizing the basic principles of project workflow. Students are expected to critically analyze the interdependencies of related workflow in product engineering process and apply the interdisciplinary principles that they have learned in starting a practical idea up. After the course, many meaningful and useful prototypes created by the students are impressive.

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