Special sub-program to enhance the undergraduate experience in NUAA

Chen Xu¹, Liu Hu²

Abstract - In higher engineering education, it is a main task to improve student’s ability to solve problems in realistic constrains. To enhance the ability, we designed a sub-program as an add-in part of a degree program. The sub-program consisted of a design-make project, a simulating situation course, and a competition. The design-make project was a researching project which was aided by the Student’s Innovative Activity Fund to foster the ability to apply for an aid, conduct an experiment, analyze and interpret data, and make a prototype. In the simulating situation course, students learnt in a process simulating a real engineering project, such as a process of designing a drill press. The competition consisted of special courses and contests, such as the Mathematic Contest in Modeling and the Contest of Designing an Electronic System. By them, students learnt and worked in a group, they had to collaborate with colleagues. The special sub-program was a practice course providing students a good opportunity to practice, and was proved to be an effective way to stimulate students to learn. As an old saying in china, students should learn by doing. Students could get credits by taking this sub-program.

Index Terms - Design-make project, Group-work, Undergraduate experience, Simulating situation learning course, Sub-program.

INTRODUCTION

In china today, universities put more and more attention on improving student’s ability to solve problems in the realistic constrains to meet the innovation demands in economy, science and technology realms. In higher engineering education, most of programs stated that undergraduate students should get, by the end of 4 years study, the basic knowledge of mathematics, nature sciences and a discipline, have abilities to apply them to conduct experiments, to analyze and interpret data, design a sample system, work with interdiscipline professional colleagues effectively, and would get improved in moral. These purposes are similar to the criteria in ABET 2000, the engineering programs must demonstrate that their student attain (a)-(k) abilities. For enhancing these abilities of undergraduate students, we developed a sub-program, as option curriculum, to provide an opportunity for students to get practice in the Nanjing University of Aeronautics and Astronautics (NUAA). There were 3 kinds of typical course and activity in the sub-program showed below.

- Simulating situation courses, such as a training course of mechanical process
- Design-make projects
- Competition activities

A student could take a simulating situation course or a design-make project. He/She could also take two or three, even all parts of the sub-program. If he/she finished a course or a project of the sub-program successfully, he/she would get credits of a course or a project. He/She could also earn credits while he/she won an award of countrywide contest. The sub-program as an add-in part of a normal program had been taken by about 20% of undergraduate students in NUAA. They won some awards in countrywide contests, such as awards of the Mathematic Contest in Modeling, the Electronic Design Contest, the Extracurricular Works Contest of Science and Technology, the Business Plan Contest, and ACM International Collegiate Programming.

SIMULATING SITUATION COURSES

The simulating situation course was a special course which was designed according to the real engineering situation to improve student’s ability to solve engineering problem within realistic constraints. In it, students would learn in a simulating scene of a real engineering project, get their experiences of solving engineering problems.

For instance, we had designed two typical course based on simulation situations, one was called as the Chief Designer Presiding over Project, and other was called as the Training Plan in Simulating Scene. The first one was a kind of project for undergraduate student. When students took this kind of project, they worked in a group simulating a realistic designing situation. For example, from February to June in 2004, 5 students, from the College of Aerospace Engineering, as a team, took the Chief Designer Presiding over Project. They began their work following similar steps of realistic designing process. One of them was assigned as the general designer, other of them were assigned respectively as a designer of sub-systems. At the first step, they done the Conceptual Design and the Preliminary Design jointly, then they done the sub-system design or the detail design solely, at the final period, they fabricated sub-systems and made flight test jointly again. In the designing process, they applied software CATIA, Airfoil Optimizer, MGAero, AirplanPDQ

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and NASTRAN, as doing in a factory or a company. They designed and built a mini electric powered remote-control aircraft named as “Lucky-bird” shown in Figure 1.

![Lucky-bird](image)

**FIGURE 1**

**THE ELECTRIC POWERED REMOTE-CONTROL AIRCRAFT “LUCKY-BIRD”**

The training Plan in Simulating Scene was another example of simulating situation courses which was developed for students to attain basic skill of operating tools and get the general knowledge of a manufacturing process. In the training plan, students learnt and did experiments in a simulating factory which was also called as a studying factory. The training plan included all parts of a whole manufacturing process, such as the designing training, the making training, the management training, and innovation training, shown in Figure 2. For an example, in the designing training part, student would learn how to design a consumable instrument or a tool on computers by applying the CAD / CAM / CAE/CAPP/CAT software, students would learn knowledge and skills in designing a product, or fulfilling an innovative idea proposed by them.

### Designing training (1)
- Learning how to apply CAD / CAE/CAPP/CAT/ PDM
- Product designing
- Etc.

### Making training (2)
- Casting
- Welding
- Machining
- Etc.

### Management training (3)
- Human resource management
- Finance management
- Process management
- Providing and Selling

### Innovation practicing (4)
- Learning how to bring the innovative idea to actual
- Project analyzing
- Product designing
- Etc.

**FIGURE 2**

**UNITS AND TRAINING PROJECT**

**DESIGN-MAKE PROJECT**

For improving student’s ability to do research, a Student’s Innovative Activity Fund was established in NUAA in 2002. The fund, being managed by a committee, was used to support students to fulfill a project on science, technology, economics, or humanities which were proposed by students or teachers.

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A student, applying for the fund, must be with the GPA higher than 2.0, and must have a supervisor with a profession title or a lecturer title. His/Her proposal was appraised and recommended for the fund on the basis of the following criteria:

- **Achievement:** When a project was implemented, there must be a prototype of a design or a paper published on a journal. The assessing panel appraised student’s work on it.
- **Plan:** The proposal must be clear and reasonable. The plan to implement it must be feasible. And there were tools and equipments for doing experiments or data analysis.
- **Extent:** It must be useful to enhance students’ abilities to make an investigation, analyze and interpret data, to conduct an experiment, design a system or a component, to build a mathematic model of a social phenomena or an economic model through the project.

For enhancing students’ experience of doing research, the committee set a fund management regulation. Students applied for a fund in a similar process to applying for a research fund, showed below.

- Download a guide putted on net by the committee.
- Chose a project on the guide, or made a proposal.
- Found a supervisor and make a work plan.
- Fill in an application form.
- Check the funded projects list on net, released by the review committee.
- Fill a confirming form and start researching work.

During the preparing period for the application, students had to do pre-research work, such as collecting references, making an analysis, consulting a supervisor about the plan, and so on. In the application form, they filled in the participants, the purpose and main work, the significance, and scientific merit (also including the extent to increase basic knowledge or stimulate additional research), an analysis of the background about it, a work plan, an anticipative outcome, a budget plan, and a comment of a supervisor.

When a proposal was funded by the Fund, students would fulfill it. The normal fund period was one year. If an extension of time was requested, the committee might usually approve a time extension for no more than one year beyond the original grant period. At the end of the project, student need to hand in a research report, a prototype, and papers published on journals. The committee rewarded certifications to the top students who get excellent outcomes in research every year, and rewarded credits to students on the basis of outcomes and their work.

From 2002, the committee of the Student’s Innovative Activity Fund has supported 145 proposals. In 2006, students have submitted 200 proposals to the committee.

For example, in 2004, three student (Liang Tianlong, Sun Fangfang, Gu Ting), from the college of mechanical engineering, submitted a proposal on long-distance experiment technology in mechanical engineering. Their proposal was funded with RM5000 Yuan (about $650.0). By Fund supporting, students developed a long-distance experiment
system based on internet technology by which students could do mechanical experiments in long distance. In this project, students had solved several of key technology problems,

- Building virtual devices of mechanism, such as Geneva gear and Geneva wheel, slide-crank mechanism.
- Remote controlling and process monitoring real-time on web.
- Integrating mechanism, sensor, actuator and controller.

Finally, a collaborative experiment platform, among the college of mechanical engineering of NUAA, Zhende Polytechnic College and the Engineering Training Centre of SCUT, was developed. And 77 of students had done experiments on it in NUAA campus.

**COMPETITION ACTIVITIES**

A series of contest, as extracurricular activities, were held in NUAA to motivate students to attending engineering practice, shown in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Contest</th>
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<tbody>
<tr>
<td>1</td>
<td>Extracurricular Work Contest of Science and Technology</td>
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<tr>
<td>2</td>
<td>Business Plan Contest</td>
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<tr>
<td>3</td>
<td>Electronic Designing Contest</td>
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<tr>
<td>4</td>
<td>Embedded System Design Contest</td>
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<td>5</td>
<td>Robot Design Contest</td>
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<td>6</td>
<td>Mathematic Contest in Modeling</td>
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<td>7</td>
<td>Corporation Identify System Contest</td>
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<tr>
<td>8</td>
<td>Notional Flight Contest</td>
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<tr>
<td>9</td>
<td>Programming Contest</td>
</tr>
<tr>
<td>10</td>
<td>Entrepreneur Forum Contest</td>
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<tr>
<td>11</td>
<td>Web Design Contest</td>
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</tbody>
</table>

These contests were held very year as a series of extracurricular activities for students. There were an approximate 10 percent of undergraduate students who attended these contests, and got credits. As shown in the Table 1, the contests were designing or planning activities, and were opened to every student in the NUAA, by which the university provides good opportunities for students to get experiences of designing and planning. Usually, a contest consisted of lectures, a designing work or planning work, a work exhibition, and a competitive examination on oral.

We take the Business Planning Contest as an example to demonstrate the process of a contest and to show how students to learn in a group and get an experience.

The Business Plan Contest was held every two year in NUAA. There was a contest committee being in charge of organizing the contest. A contest included two rounds competition, showed as following:

- The contest committee released information of a contest process.
- Students found a supervisor (advisor) and made a proposal.
- Students formed a group, about 5-7 students in each one. The group should include a student from engineering department, a student from the business department, and a student from the law department.
- Students took training lectures or courses.
- A review panel of a college appraised students’ proposals, as the first round, and built a list of recommendation for final competition.
- The review committee of the university held the final competition. Students displayed their business plans to reviewers and attended a competitive examination on oral.
- Rewarded the top works.

Works, entering for the final competition, would be appraised and recommended for rewards on the basis of the following criteria:

- **Feasibility**: The business plan must be practicable.
- **Innovation**: The production must be a high-tech item and be with a high competitive power.
- **Reasonable scheme for investment**: The plan must have the ability to get venture capital investment for the developing of the business.
- **Benefit**: The plan must be with high growth potential.
- **Oral presentation**: Every one, entering into the final stage, would give an oral presentation to the review committee and might be asked to respond some questions pointed out by judges.

The top winners of the final stage would receive a cash prize, a certification, and credits.

Because of the purpose to hold the Business Plan Contests in NUAA was to provide an integrative learning experience for students, to provide an opportunity for student to enhance the practice experience, so that, in the contest period, the committee also held a series of lectures on business for student to take, shown in the Table 2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Lecture</th>
<th>Hour</th>
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<tbody>
<tr>
<td>1</td>
<td>Project Management</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Company Strategy and Plan</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Finance Management</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Risk Management and Market</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Company Act, Contract Act and Patent Act</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Introduction of former winners and their works</td>
<td>4</td>
</tr>
</tbody>
</table>

Contestants of Business Plan Contests took these lectures while they worked for a contest. Lectures were important parts of a contest, by which contestants could learn relative knowledge systematically, get skills to make a plan.

In 2004, 9 students, coming from air flight design and engineering department, business and market department, and broadcast and TV news department, formed a work group.

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They submitted a proposal to establish a company in which they manufactured a high-tech product that was used as a maintaining material for repairing a break in an airframe or a gas piper. They called the company as XunJie Maintaining Tech Ltd. They went through to the final stage, and won the golden Cup Reward of Countrywide Business Plan Contest in Xia Men of Fu Jian Province.

**COURSE DEVELOPMENT**

As we have mentioned briefly at the introduction paragraph, the purpose of the sub-program in NUAA was to improve students’ abilities to:

- Design a system, a process to meet desired needs with in realistic constrains such as economic, environment, social, political, ethical, health and safety, manufacturability, and sustainability.
- Define problem of engineering and business, economic, and formulate, resolve them.
- Work in a group of students coming from deferent disciplines such as an engineering, economics, business, law and art.
- Collect information for resolving problems.
- Analyze data, model the problem and make a forecast.
- Communicate with interdiscipline professionals.

For fulfilling these, there were three key factors impacting on the effect of a course or activity. The first one was a student behavior in a course, an active activity would bring out a high effective learn and a passive action would result in a low effective learn. The second one was if students were equipped with knowledge and skills to solve a realistic problem. The third one was if there was a lab in which students could conduct experiments and make prototypes.

**I. Course Model**

When we developed the sub-program, we emphasized that there must be a series of lecture, a simulating situation of realistic work for students to practice, a supervisor to tutor students timely. Courses must be based on the student’s work process. Courses must be organized in a typical model shown in Figure 3. For example, the design-make project was designed based on a 4 steps of designing process.

**Advising (Supervisor)**

| Proposal, Pre-review, Design | Basic knowledge course, Theme lectures |

**FIGURE 3**

**GENERAL COURSE MODEL**

The main part was student designing process. In the process, students submitted a proposal firstly, a review panel appraised the proposal and made a recommendation secondly, students designed and made a prototype thirdly, and students gave a presentation to a review committee and hand in a work report finally. For supporting the process, we developed some option courses such as electronic system designing, electronic Lab, mechanical Lab, and so on. We also built six labs for students to do experiments.

In the design-make project, students could take a course or attend a series of theme lectures to get relative knowledge which was not taught in a normal program. Courses or lectures in the sub-program were integrated into the whole design-make process. In fact, the design-make project was an integrated learning and practice process. In the process, students learnt by doing. In doing process, students were inspired by a challenge to fulfill their proposal, learnt new knowledge and reorganized knowledge according to the need of a project, and made a prototype and do experiments with active attitude.

**II. Course Kinds and Focus**

Although all of the courses and activities were developed to improve abilities mentioned above, the focuses of different courses and activities in the sub-program were different. According to main effects on student learning, we could divide them in to 4 groups.

- **Simulating situation courses**: focus more on getting a working experience in a simulating producing process. In a simulating situation course, the content of a course was organized according the process of a realistic designing, making prototype, and conducting an experiment in a factory or a company. Students did a designing work in a simulating situation of a realistic designing work. After the course, students would learn how a real designing work to be down, and learn how to use a skill, a tool in a realistic situation.
- **Design-make projects**: focus more on the researching experience of an innovation activity. As mentioned, the Student’s Innovative Activity Fund is established to fund designing and making activities. Students, who took this kind of project, would apply for the Fund as making in a realistic research project, make a prototype and do analysis, and so on. After the project, student would learn how to apply for a research Fund, how to search reference materials, how to conduct an experiment and analyze the data, how to write a report.
- **Contest activity**: focus more on abilities to solve problems with knowledge and cooperate with colleagues in work. This kind of contest activities included an electronic design contest, a contest of student extracurricular works of science and technology. In the contests, students would finish a designing work in a group. As in the electronic design contest, the contest committee set two subjects, and a group of 3 students chose one and designed an electronic system with the set demands in 3 days. In the contest, student would show their ability to design an electronic system. So that, in the preparing period for contest, we provided special Lab course for students, such as an Embedded System Design.

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• **Contest activity II**: focus more on the integrative learning experience. This kind of contests was an interdiscipline cooperation activity such as the Business Plan Contest. In the contest, a group of students, coming from different departments, worked in a group to make a business plan, they would learn how to establish a company, how to transfer a new design into a product to bring incomes to the company. As we mentioned in CONTEST ACTIVITY, it was a typical interdiscipline learning experience.

### III. Building Lab

We had built 6 student design labs in NUAA, showed in Table 3, for students to fulfill their proposals and do experiments.

<table>
<thead>
<tr>
<th>No.</th>
<th>Contest</th>
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<tbody>
<tr>
<td>1</td>
<td>Aircraft Lab</td>
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<tr>
<td>2</td>
<td>Electronic System Lab</td>
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<tr>
<td>3</td>
<td>New Energy and Power Lab</td>
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<tr>
<td>4</td>
<td>Machine Tool Lab</td>
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<tr>
<td>5</td>
<td>Intelligence System Lab</td>
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<tr>
<td>6</td>
<td>Embedded System Lab</td>
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</tbody>
</table>

A student design lab was a workshop for student to design a system and make a prototype. For example, there were three work areas in the aircraft lab. The first one was the designing area, the second one was the parts building area and the third one was the assembly area. In three areas, students could make conceptual design and detail design, build parts of an aircraft, fabricate sub-systems and assemble a mini electrical-powered aircraft respectively. In the lab, we equipped 2 kind of necessary tool for student.

- **Design and analysis tools**: We equipped CATIA, Airfoil Optimizer, MGAero, AirplanPDQ and NASTRAN.
- **Making tools and experiment equipments**: We also equipped equipments and instruments (including vice benches, multi-meters, and oscillographs) for students to make a prototype and tested it.

### IV. Assess and Grade

Students could earn credits by taking one of courses in the sub-program. The mark and credits were assessed by a committee named as the Review Committee of Student Activity in science and technology. The committee assessed an outcome by three criteria:

- **Course Kind**: A course was set credits according to its content.
- **Work**: Student had to finish all work and hand in a report to the committee to apply for credits.
- **Oral presentation or examination**: After students had finished their work, they had to give an oral presentation to the review committee or to attend an oral examination hold by the review committee. By it, the review committee assessed the learning outcome including knowledge, abilities to solve problems, communicating skill with colleagues, and so on.

About 20% of 3900 undergraduate students had taken some of courses or activities in the sub-program in every year. They earned credits and got intensive training. Usually, a student could earn 1-4 credits by taking one of courses in the sub-program. The credits and mark would be filled in his/her school report card.

### CONCLUSION

For enhancing students’ experience of learning and solving problem with the realistic constrains, a special sub-program had be developed in NUAA. As a student saying after a contest, “I and my colleagues have learned how to study, to analyze problem, to cooperate with colleagues from different disciplines.” He, being a third year undergraduate student from electronic engineering department, attended the Countrywide Extracurricular Work Contest of Science and Technology in 2005. His team got the second reward in final contest. Teachers also gave very high praise to the program that any one of the courses in the sub program was based on a problem, students who took it had to work in a group, to learn new knowledge and skill to analyze a problem and to conduct experiments, to inspire with each other to overcome difficulties, so that they could get an integrate learning and an intensive training in the program.

In the following years, we will develop more courses and attract more students to join them. As we have mentioned above, we have developed some courses and activities in the sub-program, but there is a question for us to solve that if there is any new course or how to organize lectures, tutoring and practicing systematically to enhance practicing experience of students effectively. We also are looking forward to get companies support of providing design projects and fund titled with company name for students. A realistic project will give students more stimulation and let them get a comprehensive experience of integrating learn.

### REFERENCES