# HOW TO CULTURE INNOVATION COMPETENCY IN NETWORK PRINCIPLE COURSE

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## ABSTRACT

Advanced higher engineer education must provide not only the discipline-specific fundamental knowledge, but also competencies and attitudes demanded by the labor market. Innovation competency, one of the popular concepts in the economy field, is considered to be the key component for improving the productivity, increasing the quality of products and decreasing production costs of companies. So the innovation competency should be cultivated by higher education, especially by application-oriented high engineer education. However, it is less discussed how to combine the innovation competency with professional courses. This study focuses on the cultivation of innovation competency in computer network principle course of network engineer specialty. We will introduce it from the course contents, teaching methods and pedagogy to assessment and evaluation. At last, the outcomes are discussed.

## KEYWORDS

Innovation competency development, computer network principle course, course content, pedagogy assessment and evaluation, Standards:7,8,11

## INTRODUCTION

This century is full of competition and challenge, which forces companies to be innovative and creative if they want to survive in this new globally competitive environment. Only by constantly improving existing products and developing new products can the companies grow bigger and stronger. Being the main body of enterprise innovation, employees have been considered as one of the most important sources for firms to remain competitive in a dynamic business environment (Wang et al., 2015). Employees are mostly the product of higher education and higher engineering education, so colleges and universities play the fundamental role in training innovation competency to facing challenges of the future. That is to say, advanced higher education, especially the higher engineering education must provide not only the discipline-specific fundamental knowledge, but also competencies and attitudes demanded by the labor market.

Many colleges are aware of the significance of training innovation competency of college students and have done many efforts to import innovative mechanisms into engineering education. For example, technological universities in Russia have integrated development of territory, based on mutually profitable interaction between the industrial enterprises and universities. This provided an opportunity to develop long-term persistent demand for innovations and to broaden considerably the domestic and international high-technology

products market presence (Kupriyanov R V et al., 2015). And some technological universities in America have focused on tackling the issue of culture change in engineering education by developing a framework of educational innovations (Melsa J L et al., 2009). They emphasized that the education activities should be closely in harmony with engineering practice, in a real and complex project environment, aim at the practical need that “modern engineers need to participate in product, process and system life cycle stages of work” to cultivating students (Ye M, 2013). Realizing the importance of discipline-specific specialists to engineering projects, some universities in Canada have introduced an elective series of courses to further reinforce problem solving skills and product innovation ability (Strong D S, 2012).

When innovation competency training becomes the heart of the higher engineering education, curricular architecture, teaching mode, the roles of students and evaluation mechanism should undergo corresponding changes. As the basic units of specialty, professional courses and professional basic courses should become the most important components of innovation competency training. However, many existing research literatures about innovation competency training have more focused on the macro level of specialty framework and not paying enough attention to the comprehensive construction of specific course. In this paper, we describe the design and implementation of case studies through computer network principle, which is the professional basic course of network engineering specialty, as an example for training innovation competency. And above research work is finished under the framework of Innovation & Business Start-Ups education reform for Dalian Neusoft University of Information (DNUI) (Tao W et al., 2014).

The remainder of this paper is organized as follows. First, we give a brief definition of innovation ability trained in computer network principle course. Next, we describe the case studies in terms of the course contents, teaching method and examination mode. Finally, we introduce the effects and put forward some suggestions for further reformation.

## THE DEFINITION OF INNOVATION COMPETENCY IN COMPUTER NETWORK PRINCIPLE COURSE

Because of multiple facets and bases for interpretation, innovation ability can be defined from various perspectives (Crossan M M et al., 2010). Generally speaking, there are two ways of looking at innovation: either as a final output or as a process innovation. From the point of process-oriented perspective, innovation focuses on the accumulation of knowledge and experiences. Then the innovation competency in engineering education contains three dimensions (Berglund A, 2013): (1) problem solving ability (2) process improvement ability (3) knowledge transformation ability. On the basis of above definition, three aspects of innovation ability are chosen by considering the characteristics of network engineering specialty: judgment, practical ability and research ability. The judgment ability involves analytical ability. The practical ability concerns on the ability of discovering problems and solving them. The research ability reflects self-learning ability, logical thinking and breadth of knowledge. All the three aspects of innovation should be continuous trained by professional course, so they should be enhanced in computer network principle course.

## DESIGN AND IMPLEMENT OF TRAINING INNOVATION COMPETENCY

In order to train innovation competency of students, we should focus on the following aspects:

(1) Switch students' role and make them be active in learning process; (2) Renew teaching contents and make students understand design pattern and grasp the tendency of technology; (3) Instil students' technical skills by experiments and projects with engineering background; (4) Evaluate students' learning processes scientifically based on multidirectional evaluation mechanism and may better reflect the teaching effects. (5) Other resources configuration. Next, we will give the details about reforms.

### *(1) Peer teaching make students be active in learning process: strengthen research ability*

Innovation competency training in engineering education has proposed that students must be active in their learning processes (Sheppard S D et al.,2008). Meanwhile, Smith(1998) pointed out the importance of mentors and peers for developing of engineering expertise. And there is extensive evidence that peers help students become active learners, especially in the in-depth study of materials, analysis, and formed a distinctive knowledge system.

So all the students are required to teach a small portion of the subject matter for 10-15 min to their fellow classmates in computer network principle course. About ten topics which have different scores for difficulty levels are released at least one month in advance. Teams of two students constructed on a voluntary basis freely choose one of the topics to prepare it and all the students will get corresponding marks base on their individual performance.

After each team choose the topic for delivering, the course teacher gives guidance on acquisition of new materials, content organization and teaching skills. The guidance makes the students gain not only confidence on teaching but also experience the transformation in them from passive receivers into active participants. In addition to the time spent with the instructor in receiving guidance, the students usually spend about 3-5 hours in preparing for their delivering topic. In order to encourage active learning, all students are allowed to ask questions and take part in the discussion in the class dominated by their fellow classmates. Especially, students asking the most valuable question will gain extra marks. Therefore, all the students are informed before the class and they should prepare for questions about the topic.

During the students' delivering part, the teacher plays in a dual role. On the one hand, the teacher is a student and he can make comments, even ask questions. On the other hand, the teacher is a teacher and he is responsible for the normal operation of the class by asking question or arousing student enthusiasm of active learning.

### *(2) Understand design pattern and grasp trend: strengthen judgement and research ability*

Design patterns originated in the building field are described as a way of inheritance on successful methods of construction from craftsmen to less-inventive people. That is to say, design patterns can reflect the technology heritage and development. By introducing design patterns of internet, we hope that students can finish the inheritance then find driving force of the technological innovation and development.

In order to introduce design patterns of internet, we share eight topics to the students. Seven controversial topics of them are related to the history of internet (Day J, 2007) and the last

one, software-defined network (SDN), represents the future of technology. All the students are split into 8 groups according to eight issues. They finish literature reading and group discussion after class in order to make literature review and comments on the documents in the class. At last, each group need to submit a report on core technologies and solutions on development of computer network. Specifically, the literatures on certain topic can be given by teachers or searched by students themselves.

***(3) Experimental learning instils technical skills: strengthen practical ability***

Current practices suggest that engineering graduates should be proficient at technical skills. SIGITE IT Computing Curricula Guideline (2008) also strongly recommend to incorporate hands-on lab components into teaching in order to improve students' technical skills. Not only because the hands-on laboratory environment sparks students' interests and practice, but also because it helps students to improve technical skills. In principle, training of technical skills can be accomplished by various approaches in different major courses. Among all the approaches, experimental learning is often referred as an effective means to instil technical skills by high quality experiences with complexity and fidelity. Especially, experiential learning is the expression of "learning by doing" (Kolb D A, 1984) and it is also the core feature of TOPCARES-CDIO educational model(Tao W, 2011) developed by DNUI.

Based on the core technical skills trained in computer network principle course and error-prone points occurred in trouble shooting of engineering practice, we designed four unit projects and one course project, the relationship among them is shown in Figure 1.

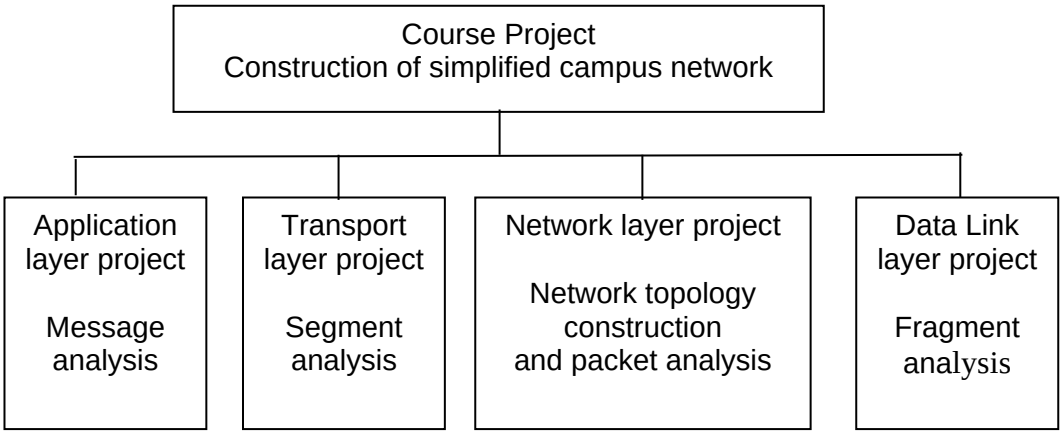


Figure 1. The relationship between the course project and unit projects

Course project is based on unit projects but is more complex and comprehensive than unit projects. Network layer project focuses on the construction of network topology with Packet Tracer (PT) software and other unit projects more concerns on capturing and filtering packets with Wireshark. While the course project includes not only constructing network topology (The topology is shown in Figure 2) but also analysing packets. In order to bring students creativity and motivation into full play, course project is only specified the basic functional points and experimental instructions. And students must implement at least two additional functions if they want to get innovative marks.

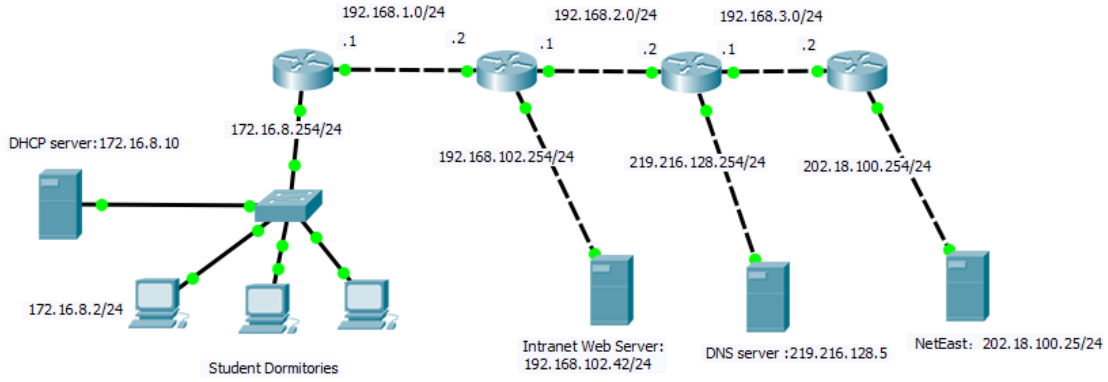


Figure 2. The network topology of course project

PT software can simplify the process of constructing topology and helps students check the outputs of network whenever they have time and wherever they may be. However, its functions are very limited relative to reality equipment in trouble shooting. In order to compensate for the limitations, basic and comprehensive experiments on real devices about debugging of protocols and services configuration are assigned to students as extracurricular experiments. And, the mistakes made by students in doing experiments are reorganizes as new experimental resources.

By means of configuring protocols and analyzing structure of datagrams in different levels, students understand not only abstract network protocols but also how to take these protocols into practice into networks. Besides that, students are also required to read and write source codes of protocols so as to understand the mechanism of network. According to the importance and complex of protocols, some source codes are provided directly, some codes are provided partly and some simplified version are written by students themselves, then all the source codes are integrated into a whole protocol stack program. By running the program, students can understand the process of reconciliation package, routing mechanism of routes and forwarding mechanism of switching.

### *(4) Multidirectional evaluation mechanism: examine innovation ability*

Examinations and tests are an indispensable components of the teaching and learning, used to examine the effects of teaching and learning. Therefore, it has become an important part of the teaching reform to find a proper examination method and evaluation system, which can evaluate students' learning processes scientifically and can better reflect the teaching effects of the courses.

Traditionally, the most frequently used assessment is closed book exams, which main check students' ability of remembering knowledge and principles. However, this method can't effectively evaluate students' learning process and other abilities. While the purpose of learning is to complete the migration from knowledge to ability, understanding to applying, inheritance and innovation, from this point, closed book exam is not sufficient. Therefore exam method reform of computer network principles should adopt a wide range of examination mode, make theoretical knowledge combine to practice and pay more attention to students' innovative abilities.

Based on the above principles, the examination method of computer network principles ranges from single terminative evaluation mode to combine formative assessment concentrated on the learning process with terminative evaluation emphasized on abilities to solve problem and fast-learning. And the percentage of two parts is 50 per cent and 50 per cent respectively. The details of them are listed in Table.1.

Table 1. Examination methods

| | Items | corresponding ability | percent | criteria |
|---|---|---|---|---|
| Formative assessment (50%) | Peer teaching | analytical ability 50%; solve problems ability 85%; self-learning ability 85% | 10% | Quality of the oral presentation (35%); Quality of time management (15%); The correction of answering question (35%); Overall expressiveness (15%). |
| | experiments | analytical ability 100%; solve problems ability 100% | 15% | Quality of experiments on PT (50%); Quality of protocol stack program (50%). |
| | course project | analytical ability 35%; solve problems ability 70%;self-learning ability 20% | 15% | The correction of answering five questions (5% each); documents (30%); Quality of PT files (35%); innovative function points (20%). |
| | literature review and comment | analytical ability 100%; solve problems ability 100%;self-learning ability 100% | 10% | Quality of literature review (30%); Quality of comment (30%); Quality of document (40%) |
| Terminative evaluation (50%) | solving problem | analytical ability 100%; solve problems ability 100% | 35% | Network of debugging (50%); analysis of packet files (50%) |
| | fast-learning | analytical ability 50%; solve problems ability 50%; fast-learning ability 50% | 15% | New knowledge learning (50%); solve problems using new knowledge (50%) |

From Table 1, we can obviously find that the sum of percent on ability is greater than 100%, which is due to the calculation method that accumulates the score corresponding criterion. Then we can deduced the score of different abilities in Table 2.

Table 2. Score of different abilities

| Ability | Score |
|---|---|
| analytical ability | 77.75 |
| solve problems ability | 86.5 |
| self-learning ability | 33.5 |

For quality of the oral presentation in peer teaching, panel of judges composed of six students and one instructor grade it on a five-point scale(5=Excellent, and 1 =Poor).As for the questions in course project, they are all about trouble shooting or specific operations in construction of topology. Obviously, the extracurricular experiments are not involved in the part of formative assessment, but the points will be directly deducted from

formative assessment if the students can't hand in the lab reports timely. As we can design, the termination exam is a computer-based test and the exam questions put emphasis on network debugging and packet analysis, specifically, the termination exam contains some questions about new knowledge, which is never involved in class, to examine the fast-learning ability of students.

### *(5) Other resources configuration*

In order to provoke students' enthusiasm and make them become the active participants in learning, we provide students comprehensive support as supplement of classroom teaching, such as MOOCs platform, online resources of Cisco Network Academy, Opening laboratory and ordering, club activities, technical presentations and networking competition.

## EFFECTIVENESS EVALUATION

Since 2008, continuous improvements in course construction play important roles in the whole course realization process. This extends into every aspect of course, from initial course project down to the reform of examination. Obviously, this process is actually a huge challenge for students and teachers, and the challenge is not only misunderstanding from students and additional workload to the teachers, but also the risk of delaying teaching schedule. Fortunately, we often finally find effective methods to solve them.

By evaluation and comparison, there is an improvement to some extend in analytical ability, problem-solving ability and self-learning ability by averaging the values of examination corresponding ability point each year. Figure 3 presents the changing curves of ability improvement. And Figure 4 presents the differences of three abilities by comparing different stages of semester. To be fair, the comparison is executed on same measurement terms. Judging from the result, students' abilities are improved in a certain degree, especially the problem-solving ability. Therefore, we acquire the expected results of reformation. But the question remains, such as how to effectively mobilize the learning initiative of students and how to greatly improve the self-learning ability. All these need to be further explored.

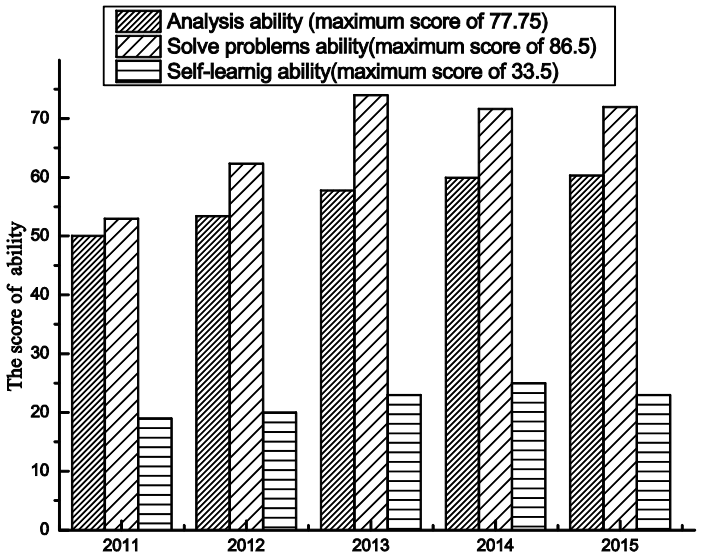


Figure 3. Changing curve of ability improvement

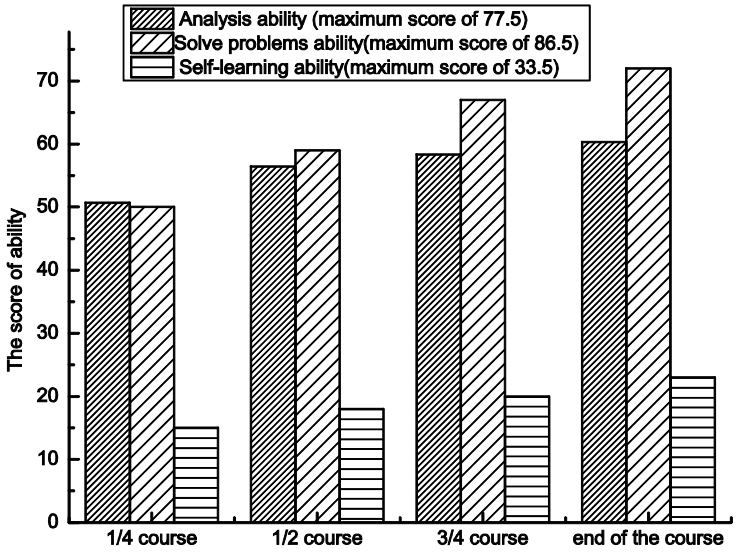


Figure 4. The differences of three abilities in different stages of semester

## CONCLUSIONS

Our course reform aims to improve innovation competency of students in network engineering specialty. To achieve the goals, we start it from the transformation of student-role, the update of course contents, instilling students' technical skills to multidirectional evaluation mechanism then significantly train judgment ability, practical ability and research ability, i.e. three parts of innovation competency. Practices show that students' innovation ability has been improved in a certain extent.

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