Teaching content and methods in a *Computer Network* course and its effect on a local university

Xuemin Zhang, Zenggang Xiong, Yaomin Ding, Guangwei Wang & Conghuan Ye

Hubei Engineering University
Hubei, People's Republic of China

ABSTRACT: A course in computer networks is a key professional course for computer science and technology majors in China. It is a practical major course, and it is very important for students to master this course well, so that they can acquire the ability to solve practical problems. It has been found that traditional teaching methods are not particularly suitable for this course. Therefore, the authors of this article present and discuss a teaching reform for computer network courses offered in local universities in China. The article deals with the introduction of teaching content reform, and explores some teaching methods and teaching modes' reforms based on teaching practice. The authors also analyse the effect of evaluation in the teaching reform. It is anticipated that the teaching reform will help raise students' interest in learning, promote curriculum development and improve teaching/learning outcomes.

INTRODUCTION

With the improvement of the flow of social information, the role of networking in social development has become increasingly important; users also place more stress on the quality of computer network technology than in the past. The demand for networking and technical personnel both in quantity and quality is constantly increasing.

As a basic course for training computer network professionals, *Computer Network* and other related courses in computer-related professions are becoming more and more prominent, with the *Computer Network* course becoming the core course in computer science. This course is also one of the compulsory subjects of the computer-related professional and postgraduate professional courses [1].

The characteristics of a computer network course are quite complex. There are so many new concepts in it, and it is also a highly theoretical course, as it deals with very abstract concepts and ideas. When studying this course, students often want to acquire some application operation skills related to computer networks, and are not as interested in the basic principles of the course. Thus, they do not pay particular attention to the study of this course. Some even experience anxiety when learning this course. Therefore, improving the teaching level and quality of the computer network course is of paramount importance for students and teachers, both in the learning of the course, and in the follow-up research and practice. In their academic engagement, the authors of this article also pay great attention to teaching related research so as to improve teaching quality. Three fundamental aspects of the teaching reform of the computer network course are presented and discussed in this article.

TEACHING CONTENT REFORM

Computer network courses offered in universities generally consist of five layers: the physical layer, data link layer, network layer, transport layer and application layer. Each of these five parts may have independent content, so from the aspect of content, the course is very complex and complicated and fewer teaching hours are available to conduct the course. So, the teaching content reform covers three aspects, namely: concept, knowledge reasoning and application. Teachers should pay more attention to developing students' understanding of the concepts and application. They should focus on typical concepts and methods, which are closely related to computer networks, and pay attention to developing students' logical thinking ability at different levels.

They must pay attention to the depth of content, and carefully arrange the teaching content for *efficient use*, to retain students' interest in learning and showing initiative for the practicality. However, teachers should not skim over the syllabus. Therefore, in order to reduce duplication of the teaching contents, the teaching programme should take the following teaching order: the physical layer, data link layer, network layer, transport layer and application layer [2].

1. The basic transmission medium should be chosen as the main means in the teaching of the physical layer of computer networks. The main points are the basic principles and transmission methods of these media. Signal communication in the physical layer should be stressed and the background information of computer science and technology should be appropriately introduced. Teachers can add some of the newer technologies and achievements of modern science and technology in the teaching process. With the help of some popularisation of science books, teachers can make abstract problems concrete, and enhance visualisation of theoretical issues. The applications of coding and modulation in computer network physical layer are particularly prominent.
2. Some concepts of the data link layer are widely used in real life. Students are also familiar with some associated equipment for their practical experiments, but they may not understand the basic principles. Lectures should be structured to ensure depth, and should focus on the CSMA/CD protocol, PPP and HDLC protocol. Students also should grasp the data link layer error control mode, the access control methods of channel division. They may also deepen their understanding of the basic concepts of flow control and reliable transmission mechanism.
3. In the network layer, teachers should place emphasis on the understanding of basic concepts and processing practical router problems. The basic concepts of the router are: routing forwarding concept; static routing and dynamic routing; IPV4 address, APR protocol; NAT address translation; subnetting principle, subnet mask, principle of CIDR classification; IPV6 address. Routing protocols and algorithms include: OSPF protocol, BGP protocol; mobile IP address should be included as the key contents. Because there is a correlation between some of the contents in this part and algorithms in the data structures course, this part should be enhanced by the theory of algorithm knowledge and describe how the practical problems can be solved by the use of associated data structure algorithms.
4. The transport layer should firstly be taught as part of the service provided by the transport layer and, then, teachers should explain to students connectionless and connection-oriented services, TCP protocol, UDP protocol, TCP flow control and congestion control principles, etc. In particular, the relationship between the TCP and IP layers should be clarified. Contents of this section should highlight the characteristics of the structure and the abstract, but because the content of these parts is too abstract, it is difficult to understand it by students. Teachers should present examples and give appropriate explanation, pointing out briefly to some applications in the computer science and technology such as TCP three-way handshake agreement. If there is a limited number of teaching hours, teachers may need to introduce some basic content, but this part cannot be ignored.
5. The application layer is highlighted in some computer applications commonly used through the network. For example: client/server model, P2P model, the basic principle of DNS system, establishing FTP server, basic principles of the e-mail server, establishing WEB server, etc. This part is closely linked with the actual application, so students are more interested in it. However, students must learn the related basic knowledge more deeply in order to understand the application layer.

With a view to improving the course delivery, the authors focused on the important teaching content component, thinking how to handle the associated contents with each part of the course through a series of knowledge junctions, so that these contents were connected and contextual.

TEACHING METHODS REFORM

Prepare lessons and carefully organise the teaching content: there are many relevant concepts in the computer network curriculum, and students find it difficult to understand and remember. Teachers should address the different narratives on the same definition in different versions of textbooks to find out the kind of definition students can grasp and accept easily. For different definitions the issue is to find out the relationship between them. For similar definitions, the objective is to find out the differences. For example, the relationship between the gateway and routing, symbols and data transfer rates, etc. Teachers should have a thorough grasp of the teaching materials, consider it repeatedly, and help the students to grasp the knowledge in the first place. Teachers should start with the basic concepts and theory, and ultimately implement the basic way to solve the problem. This is the only way for students to establish a complete system and acquire the theoretical framework, application skills and methods [3].

Explain accurately with meticulous logic: in order to make students understand abstract concepts, knowledge expansion requires concise explanations, combining the new knowledge with the students' knowledge. Teachers must grasp the concepts in teaching materials, disentangle the threads of the content, and make no logical errors in carrying out a logical sequence. Students should be able to easily understand and master it. In particular, on the physical layer, because there are so many formulas, the teachers must be prepared in advance before presentation to be able to reflect on the characteristics of strict logic, otherwise students will not be able to understand the basic application of these formulas, nor think in a highly logical way, resulting in this part not being grasped and understood.

Use flexible methods to stimulate students: teachers should constantly seek to find a good method to stimulate students' interest in learning. Teaching methods can be applied in various forms. For example, teachers may use methods, such as the *analogy method* where there can be no differentiation without contrast. The various parts of the computer network course are both independent of each other, but also form an inseparable whole. Some concepts are easily confused by students; the comparative method can be carefully analysed to find the similarities and differences, and to reveal their common things standing a proper height in the teaching process. Often students can understand the concepts deeply, such as the relationship between the protocol and algorithms, relationship agreements with the service and so on.

Combination of concrete and abstract: many of the concepts of computer networks are abstract, if the definitions are given bluntly, it is often difficult for students to understand them. Teachers should first give a specific example and, then, introduce the abstract theory, which may be easier to understand. In order to explain how the PC can find the other computers in data link layer, teachers should give a real life example of how to find a student on the campus. This makes it is easy for students to imagine when one explains the concepts, to understand the basic principles.

Combination of theory and practice: introduction of practical examples of network applications stimulates student interest. For example, there is a flood somewhere; leaders go on patrol, usually taking the highway, but due to the flood waters washing across the highway, the leaders must take a different path to reach their destination. This is the routing selection problem in the network layer. Combining theory with this practice, so that students can feel the practicality of computer networks, will improve students' interest in learning, and enhance students' ability to analyse and solve problems.

Attention to summary: although *computer network* is a *loose* concept, the architecture, detail and the unity can be combined overall, and each chapter can be a string in the main thread. These contents tie up closely by layering thought to reflect the hierarchical architecture of the entire computer network. Thus, teachers can let students actually understand what a computer network is, and how to use a computer or network to solve classic or real problems, so as to achieve the purpose of teaching.

*Timely training, infer other things from facts: t*eachers prepare lessons and exercises at the same time. Consulting a large number of problem sets to identify ideas for problem-solving will help to train students in logical thinking and abstraction through classroom and school practice to distinguish different concepts and avoid confusion. So that students can learn by analogy, more abstract knowledge of the network layer must be mastered through a variety of exercises and tasks, at which point the intensity of training will increase. Hence, the selection of exercises should be based on of certain identity, reflect comprehensive and typical applications. Exercises that include consolidated concepts and can be directly related to computer subjects should be selected to promote the transfer of knowledge, to strengthen the basic knowledge and skills, train student thinking ability, and develop the ability of analysis and solving problems.

Meanwhile, teachers should carry out the revision of tasks and questions included in the graduate entrance examination papers, as well as the network engineer examination questions in papers given in the *Computer Software Technology Test* in recent years, and intensively analyse and revise them with students. Through such a comprehensive system, students can grasp the knowledge points, and also improve their ability to integrate theory with practice, and enhance interest and confidence in learning. In class exercises, teachers should not only correct errors and provide comprehensive answers to typical questions, but should also analyse the essence of the exercises and provide a thorough analysis of the process of logical deduction, applied to a variety of ideas [4].

TEACHING METHODS REFORM

Full use of multimedia teaching improves teaching effect: the basic form of traditional teaching of mathematics is *chalk and talk*. After many years of practice this method has become a complete routine. From a certain perspective, traditional teaching methods are effective. However, traditional teaching methods have serious drawbacks, such as a large amount of writing on the blackboard, which is time-consuming and imparts less of the content. If the writing on the blackboard is not up to the standard, with inaccurate hand produced graphics, which do not adequately represent the desired images, these will affect the teaching quality and learning outcome.

The features of multimedia teaching methods are lively, interesting and informative. The use of an overhead projector may solve the problem of students' classroom practice. However, this approach also has some shortcomings. The improvisation of teachers is restricted, especially, when carrying out a proof and reasoning exercise, they need *talk and chalk* in writing down the sequence of steps for arriving at a certain proof of a formula.

At the same time, teachers guide students to follow the teachers' thoughts to comprehend the essence of the problem. Therefore, the use of a combination of multimedia and teachers' proper writing is also a kind of valid mode. Thus, in the process of teaching computer networks, coupling multimedia with blackboard teaching can improve teaching effectiveness. Multimedia software include PowerPoint, Geometer's Sketchpad, MathCAD and Maple, and so on. PowerPoint has now become a standard in lecturing, especially, when used in conjunction with Flash is very suitable for designing computer network courseware.

Full use of network-assisted teaching platform enriches teaching resources: due to the limitations of classroom teaching time, a lot of information cannot be fully conveyed to students. A network platform provides a good *secondary teaching space*, which provides a new learning mode to support independent exploration, multiple interaction, situation creation, cooperative learning and sharing resources, etc. For both teachers and students the network platform provides a powerful teaching and learning virtual environment, which becomes a bridge between teachers and students, and which promotes sharing a large number of excellent teaching resource.

The network platform can realise a multitude of teaching functions: 1) upload course materials, such as a teaching plan, computer network-related exercises, reflection questions, anecdotes or good stories, experiments, and so on; 2) release teaching-related information; 3) interact between lecturing and tutoring; and 4) create a test database, so that students do on-line exercises and self-test.

There are already many colleges and universities conducting research and practice in this area that one can learn from and follow. There is no obstacle to the implementation of such activities in the authors' university. Academic teachers can organise students to develop Web sites or teachers can do these in the form of blogs or qq groups to upload data, interact and release information. This provides students with an environment that is easy to operate in, and once completed, such a resource can be fully shared, with no repeat of the development work. However, teachers will need to carry out any necessary maintenance work. Such new developments can be done in the form of research projects, which further enhance educational objectives.

Focus on experimental aspects improves students' practical ability: the reform of experiment projects should meet the needs of society and the experimental subjects should contain a novel and practical design and comprehensive content as the selection of experiment content directly affects the students' interest in learning and teaching quality. Computer network technology is a rapidly developing discipline with application occurring across the board, so experiment contents should be constantly updated and amended in accordance with the needs of social development in order to meet the market demand.

After a full investigation based on market research in accordance with the actual hardware environments and following the requirements of network experiments, the authors designed seven experiment projects, and also developed an experiment guide book. In the experiment guide book, the projects are especially designed experiments representing a main form of exercise, provide students with information on needed equipment and tools, so that students complete their own content requirements for the proposed experiment project, and can independently realise their network plans. The objective is that the experiments allow students to deepen their network knowledge and the understanding of theoretical ideas, concepts and principles, which they have learned through the experiments. Obtaining the actual information on engineering technology to improve their practical ability and adapt to the rapid development of network technology is the overarching objective of the experiments.

TEACHING EFFECT EVALUATION

Evaluation of the effectiveness of teaching is a standard measure to examine whether teaching methods are adequate or not. Obviously, there is a variety of evaluation methods and tools, such as a natural experiment, surveys, questionnaires, interviews, statistical analysis of teaching results, etc, that can be applied for this purpose [5]. The authors used a questionnaire in their preliminary assessment of the course to gauge students' perceptions. The instrument was administered to 70 students in the 2014 cohort in the Computer and Science Department of Hubei Engineering University. There were two questions in the survey: Question 1: does teaching reform help classroom learning and mastery of content? Question 2: Are you satisfied with this teaching method? Table 1 shows the results.

Table1: Teaching evaluation survey.

Students' answers	More helpful	Helpful	No opinion	Satisfied	So-so	Dissatisfied
Student numbers	44	20	6	55	10	5
Ratio	62.9%	28.6%	8.6%	78.6%	14.3%	7.1%

From the survey results, the majority of students believe that the teaching reforms have helped learning theory and practice of computer networks, and generally like the teaching methods and modes.

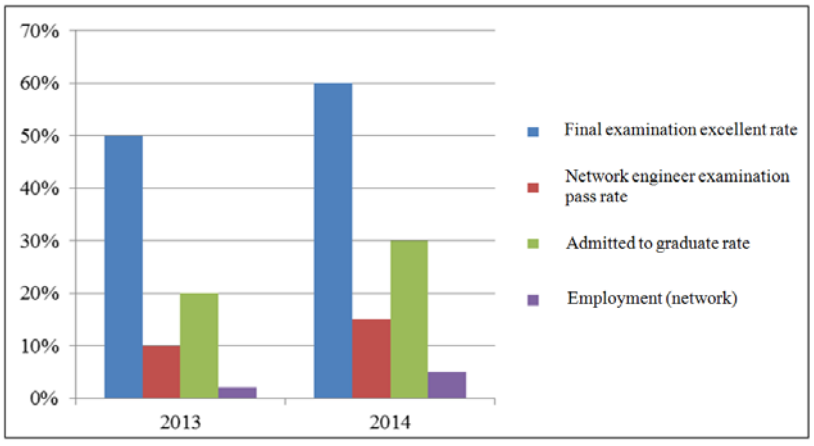

Figure 1: Before and after the reform.

The authors also performed statistical analysis on various tests in which students participated and the employment situation after the teaching reform, as shown in Figure 1. In 2013, a small number of reforms were put in place. In 2014, a comprehensive reform was conducted and results had increased significantly in that year, especially, in the final examination in which the success rate was high.

From the above evaluation results it can be see that the teaching of the computer network course improved after the introduction of the teaching methods and modes reform.

CONCLUSIONS

In this article, the authors commented on the importance of computer networks in computer science for technology professionals, and explored several teaching methods and modes of computer networks combining teaching practice with teaching models from other universities.

The teaching reform advocated for in this article could solve conflicts of fewer class hours and high teaching content, and it may also help to improve the students' interest in learning, strengthen curriculum construction, and ensure the teaching effect and teaching quality. Of course, the teaching process is a process of constant modification, adjustment and trial, hence, course reform needs several useful iterations to improve the subject's teaching and learning outcomes.

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