

Student-centred methods used in an *Instrumental Analysis Laboratory Course*

Shi Yuhua

School of Chemistry

Jilin University

Jilin 130012

People's Republic of China

Abstract

This paper describes student-centred methods in teaching an *Instrumental Analysis Laboratory Course* (IALC). A feasible method of developing students' problem solving skills in IALC is strongly suggested. The students' problem based learning, critical thinking and individual learning abilities will be greatly developed using these methods.

Introduction

In the classroom of one hundred years ago, teachers presented the lecture while students sat in straight rows listening and perhaps taking notes. In the 21st century, despite the use of electronic media in education, many teachers feel more comfortable with the traditional 'chalk and talk' techniques to deliver information. They still use the teaching method of 'I lecture; you listen and write'. Nowadays, the new generation has to contend with intense competition for students' interest. Teaching the specific knowledge is much less important than training some key skills for students, such as critical thinking, problem solving and life long learning skills. The aim of education is to give them a golden finger or how to find gold, not to give them pieces of gold. Acquiring the specific knowledge is no longer the only aim of education. Most importantly, a university teacher should know how to effectively use their teaching methods to train students' learning abilities. Through the investigation of the western teaching styles, the student-centred educational environment is more suitable for students of the new generation to develop their personality and creativity than is a teacher-centred educational environment.

What is teacher-centred teaching?

Teaching in teacher-centred environments includes:

- methods, activities, and techniques where the teacher decides what is to be learned, what is to be tested, and how the class is to be run;
- often the teacher is in the centre of the classroom giving instruction with little input from students; and
- the teacher decides the goals of the class based on some outside criteria.

What is student-centred learning?

Teaching in student-centred environment includes:

- language activities, techniques, methods where the students/learners are the focus and the teacher plays only a peripheral role;
- allowing students some control over the activity or some input into the curriculum, thus encouraging student creativity;
- group work;
- allowing students to design their own assessment;
- catering for individual styles and needs of the learners;
- is thought to be intrinsically motivating and thus beneficial; and
- the role of the teacher is to monitor the students and give advice or ideas so that they may draw conclusions and solutions independently or cooperatively.

Comparing the difference between the student-centred and the teacher-centred education, Johnson and Johnson (1989) found that student-centred education seemed to motivate students to form closer relationships with one another in working together. They scored higher academically and gained some social skills through cooperative work. In contrast, the students in the teacher-centred classroom did not spend as much time working cooperatively and thus had less of a working relationship one with another. Hayes thought that not only did the student-centred group average higher scores, they also stated that learning was easier due to the review games and group assignments. In the student-centred

presentation, the morale of the class was higher as students seemed to enjoy the competitiveness and stimulation of group assignments.

IALC is useful because the practical work always reflects realworld problems. Although the essential theory may be boring, it is the common sense nature of the practical work that is attractive to students. They can learn something different from the lecture especially laboratory techniques. It is a perfect way to understand the comprehensive and abstract knowledge, assimilate the theory and master the practical problem. Since the essential theory is not complicated to understand and the experiment is not difficult to do, the student-centred teaching and learning is more feasible in IALC than in other chemistry laboratory courses. In this paper, a suggested methodology is carefully designed since the foregoing strongly suggests that student-centred of training students' problem solving skills in IALC is highly beneficial.

Course description

The *Instrumental Analysis Laboratory Course* is a compulsory basic experiment course for third year (5th semester) undergraduate students majoring in chemistry, chemical engineering, applied chemistry and environmental science in Jilin University. It involves 48 hours of laboratory work each semester at a rate of 3 hours per week. This course is a practical application of the one-semester introduction to the basic principles that students learn in lectures on analytical problem solving using chemical instrumentation. Students will learn skills relevant to problem solving which will prepare them for a career in a technical discipline. Specifically, students will apply analytical instrumentation to the understanding of the chemical and physical principles of instrumental measurements and the operating principles of modern instrumentation (e.g., proper operating conditions, environmental variables affecting signals, and data manipulation) to practical situations. There are nine instruments available to students in our Analytical Chemistry Department. They are: an Atomic Absorption Spectrometer (AAS), an Atomic Emission Spectrometer (AES), an Ultraviolet-Visible Photometer (UV), a Fourier Transform Infrared Spectrometer (FTIR), a Nuclear Magnetic Resonance Spectrometer (NMR); a Gas Chromatograph (GC), a High Performance Liquid Chromatograph (HPLC) and an Electrochemical Analysis Instrument (EC). The instruments are used in almost all scientific research fields.

Current teaching system and methods

Teaching and learning IALC is carried out mainly in a teacher-centred style in Jilin University. In my laboratory course, the detail procedure is show in Figure 1. The teacher will give the principles and theory of the instrument, and the teacher will give the students hands on introduction to the instrument. The sample might be a blood, water, soil, air, etc., sample. The teacher always prepared it in advance because the course time is limited. In fact, finding suitable instrumental operating parameters is not an easy task for the new learners. A poor selection of

operating parameters can result in damage to the instrument. Teachers always select suitable operating parameters for students. What the students can do in the experiment is introduce the sample to the instrument and detect it. The instrument will give the data and analyse the data. A computer program does the data analysis instead . Finally, the students will present their lab report.

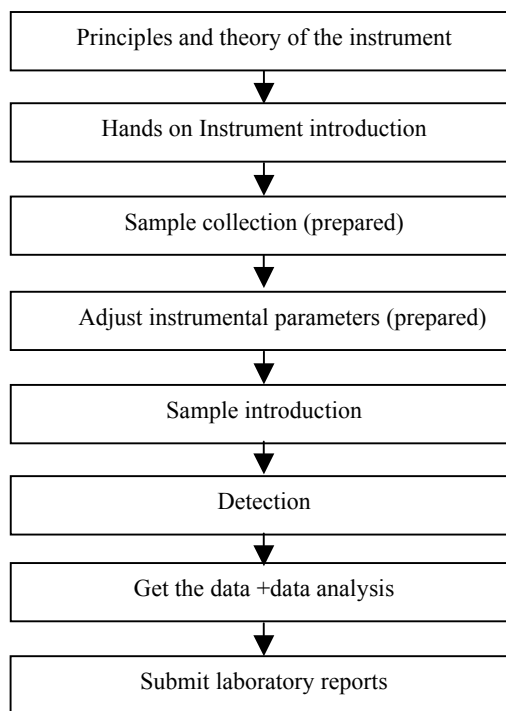


Figure 1. Detail procedure of teaching IALC

The procedure is, therefore, prepared and automatic. It teaches step by step, while students learn and practice step by step. Teachers are willing to tell students what to do step by step while students are willing to do what the teacher told them following the transfer of the specific knowledge. The teaching process is mainly teacher-centred. It is not a good method to train their skills. In order to stimulate student's creativity, I always encourage them to ask how does the instrument operate, ask them to observe the detail of the instrument structure, ask them to find the correlation between the practice and theory, give them some useful real world examples that they might meet in the future. But even so, this kind of teaching strategy still seem not to interest the students as much as I imagined. They seem to be passive learners.

Modification

Laboratory work is important because it has the potential to bring to life the concepts that are taught in class and to show students how science is based on experimentation and observation. Lectures may not be appropriate when we are trying to develop a student's problem solving skills, critical thinking and individual learning abilities, so we put effort into the laboratory work.

In order to making students become more independent, life-long and active learners, I will use some methods that I have learnt at The University of Sydney to modify my teaching strategies in teaching IALC. In order to achieve a

student-centred teaching style, three strategies are suggested: problem based learning, critical thinking and individual learning. These strategies will be interesting. The students will be actively involved in both team work and individual learning tasks.

Using problem based learning technique to train their problem solving skills.

Problem based learning is learning through tackling relevant problems. In problem based learning, the problem may not be solvable but engaging in the process of attempting to find a solution. Students decide what they need to learn by engagement with the problem. The main characteristics of this strategy are: relevant problems, creating a need to know, integration of academic and professional knowledge, and having interactive and cooperative learning.

The laboratory work could be started by a problem relating to our interesting daily life. This is an example.

In an isolated village, the villagers were ill. Their teeth and hair had fallen out and they are unable to walk or farm in their fields. What is the cause of the problem? A team of biologists had come to the village and reported that the problem is not a genetic illness. They suggested that it might be caused by environmental pollution. Imagine you are chemists. It is up to you to find the exact pollutant and/or pollution source in the environment. What would you do then? Can you help the villagers to find out the reason for the illnesses? What specific knowledge will you need to solve the problem?

From this point of view, the students will be interested in the lab work for they have enthusiasm to solve the problem. They discover what information they need by engaging in the scenario. They should integrate the knowledge they

have learned and finally would have some interactive and cooperative learning from their classmates' help. They will know how important it is to be well trained in the knowledge and skills in sample collection, instrument selection, detection and production of the report. They have an incentive to do the practical work. They will find it is challenging to study the theory and develop the practical skills. They would also develop some skills in team-work, communication, independent learning and critical thinking. That is the aim of our lab work.

Using critical thinking techniques to train their problem solving skills.

Critical thinking is the ability to use what they know to solve problems and make informed decisions. In the way of 'collection, read, analysis, assume, and conclusion' or 'obeying the rules of logic, avoiding fallacies, and building a coherent argument', they have developed critical thinking. Learners can find the right way of solving the problem by critical thinking.

Using individual learning techniques to train their problem solving skills.

It is the students who decide the learning content, the method, the pace of study and the order of the topic according what they want to and need to learn. In the process, they are active learners. The aim of individual learning is naturally to solve the problem.

My new teaching program in IALC

I have introduced three key techniques in student-centred teaching. A teaching program that will be used in my course is carefully designed to develop their problem solving skills. In my student-centred laboratory course, the overall procedure is carefully designed and shown in Figure 2.

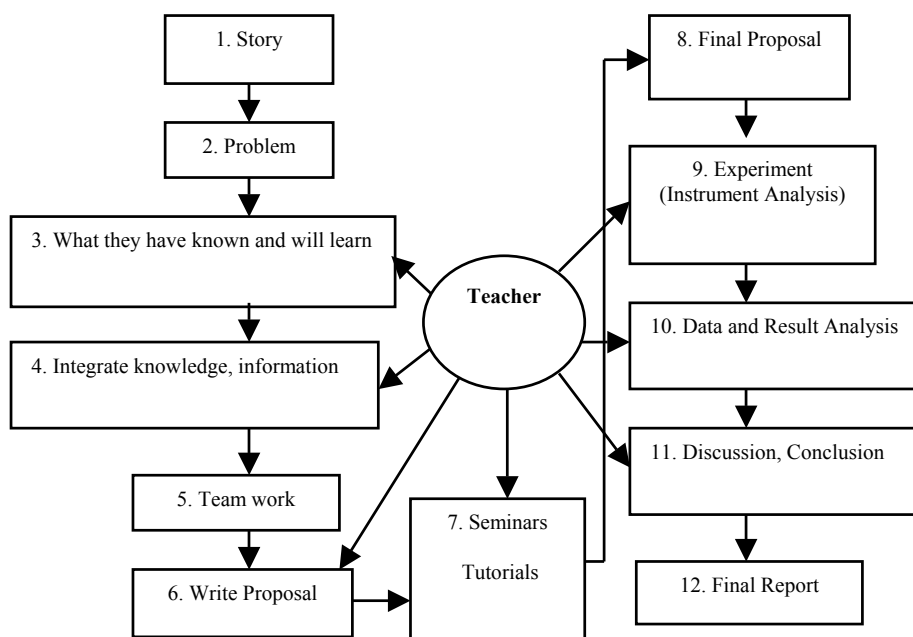


Figure 2. Overall student-centred procedure of teaching IALC

Firstly, a real-world story will be given to the students, and then we will find the problem in the story. In order to solve the problem, students need to look for relevant knowledge. After having learned the new knowledge, students must integrate the relevant knowledge and information, and design a feasible scheme. Of course, it is only a draft and generally includes some mistakes. In the last two steps, the teacher should give students a guide, which ensures student follow the right method. Students should have interactive and cooperative learning, analysing and discussing what they have learned, discuss the reasons behind their individual schemes, and finding out what they have done correctly, and what is incorrect. After discussions and argument, the students write a primary proposal. Getting all primary proposals from each group, the teacher will hold a series of seminars and tutorials to discuss and argue the proposal with each group, encourage the feasible parts in the proposal, and point out any disadvantages. After modifying their draft to create a final proposal, the students start to perform the experiment with their group, and obtain the data and analyse the results. Students develop an answer or solution. But they are asked to discuss and argue the rationality of the answer or solution. After discussing and arguing again and again, a reasonable final answer or solution will be submitted in their final report.

I also have a new idea regarding the tutorials-online component. The internet is so familiar and useful to us all. How can the internet be adapted for our teaching process? We will put the principle and theory and relevant links of our lab work online, also some video recordings of popular experiments. Although students won't have time to do the experiments themselves, we will have discussions on the topic. Questions are designed to test their pre-laboratory or post-laboratory learning. The aim of building online tutorials is to make the students open-minded, and to encourage pre-class and post-class learning. This provides useful support to the teaching activities. Teachers and students can communicate and provide/receive immediate feedback by the Internet. This new kind of tutorial is designed to develop students' individual learning abilities. It will help teachers and learners in effectively teaching.

In this program, the first five steps are designed based on problem based learning, the six steps (steps 3-6,10-11) are designed based on critical thinking. The steps 3, 4 and 7 related to individual learning ability. Without critical thinking and individual learning, students cannot write a feasible proposal. The teacher's role is sometimes a guide, sometimes an organizer and referee, sometimes a tutor.

So the teaching program concentrates mainly on student-centred activities. It is the best method in training students' problem solving skills. Compared with the past teaching method, it should greatly improve their learning abilities.

Some suggestions of the teaching program.

The teaching program is a big program, and is the culmination of our laboratory course. As the program can be separated into several parts, each learning ability and the practical skills can be easily developed step by step. Different aspects of the lab work can be designed to train students' critical thinking abilities, some to train individual

learning abilities, and some to train problem based learning abilities. We can also use this teaching program specifically in this one instrumental analysis field, if it works well, we will gradually expand the teaching program to other instrumental analysis fields. is the program provides a feasible method in developing students' problem solving skills.

Assessment

At present, the laboratory mark is divided into two parts. One is an ordinary mark derived from the experiment result and the student's involvement. This component is worth 70% of the total grade. The other mark is from the written exam conducted at the end of the semester and is worth 30% of the total grade. The ordinary mark, especially the mark for involvement is not clear for most teachers. Using the student-centred teaching style, the most important thing is to stimulate the students' problem based learning abilities, critical thinking and individual learning abilities. So the involvement mark will be evaluated by such skills. To emphasise the importance of their "effort", I plan to raise the ordinary mark to 80% while the final exam mark will be lowered to 20% of the total grade. The laboratory mark will be assessed by the following criteria:

1. Effectiveness of the lab work (20%)—student-centred (teacher guided).
2. Responsibility and independence (20%)—student-centred.
3. Developing the main idea of the special project (20%)—student-centred.
4. Information processing skill (20%)—student-centred (teacher guided).
5. Final examination mark (20%)—student-centred.

Anticipated problems

For the traditional education system, students are very reliant on their teachers. When we start the student-centred system, I am afraid students might not accept this style the first time. They must be active and put their effort in problem base learning, critical thinking and independent learning, but time is limited to them.

I am sure it is a good idea to stimulate student's learning ability, but I am not sure whether my colleagues would agree with me in the teaching style. It is a long-term project beneficial to students. I need support from my colleagues and my students.

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