Exploration of Student-centered Teaching Reform in Experimental and Practical Courses

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Abstract. In the Artificial Intelligence College of Nankai University, experimental and practical courses are important supporting the construction of our two national first-class undergraduate majors (Automation 080801, Intelligent Science and Technology 080907T). The traditional teaching mode is not conducive to the development of teachers and the progress of students. In order to adapt to the requirements of the new engineering construction and establish the guiding ideology of student-centered development, the reform of the curriculum is explored from the following three aspects: introducing the teaching tool of the Rain Classroom to enhance the interaction between teachers and students, integrating the effective teaching methods of O_AMAS to effective class design, improving the evaluation mechanism to reflect process learning. Through the reform, teachers and students are more and more active in the teaching process, a good community of teachers and students has been built, and the high-level nature of curriculum construction has been promoted.

Keywords: component; Rain Classroom; O_AMAS; evaluation mechanism

1 Introduction

Nankai University was approved to set up the major of "intelligent science and technology" in 2005 and began to enroll students in 2006. The major was established on the basis of automation major, focusing on the cross integration of information science and technology, control theory, intelligent theory, robotics, sensor technology, mechanical control and other courses, with the goal of cultivating application-oriented, research-type, development-type engineering and technical talents, focusing on training and improving students' engineering practice ability [1][2].

Experimental and practical teaching are practical teaching activities aimed at cultivating and improving skill levels. Compared with classroom teaching, experimental and practical teaching have strong characteristics of observation, operability, and integration of theory and practice. As the content of theoretical teaching is difficult, experimental and practical teaching methods can enhance teaching effectiveness, improve students' hands-on operation ability, and effectively stimulate students' research and inquiry spirit.

Based on the important role of experiment and practice in the ability training of Engineering application-oriented talents, in the course design, only by truly taking students as the center, breaking the traditional teaching mode, improving the curriculum system, effectively carrying

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out the interaction between teachers and students, and improving students' learning autonomy, can we comprehensively improve the quality of course teaching and meet the goal of talent training in the new era.

2 Basic elements of reform

In the traditional experimental and practical teaching process, students often have a strong curiosity about the experimental equipment as soon as they enter the laboratory, eager to operate the experiment directly, and neglect some principle problems, resulting in many low-level errors. Sometimes even some mistakes will damage the experimental equipment, which will directly affect the follow-up course. Most of the students still stay in the way of previous verification experiment in the process of practice. They do experiments directly. If they have problems, they find teachers or teaching assistants to solve them. They lack the ability to think and analyze on their own. In the process of practical course guidance, teachers also explain and guide students by experience because they do not know the basic knowledge of each session of students. However, many problems that are repeatedly emphasized still cannot be taken seriously.

Based on the above problems presented in the experimental practice course, our teaching and research group carefully analyzed, adhering to the student-centered concept, with the purpose of improving students' ability and interest in learning as the means, carried out the following three attempts:

2.1 Introducing the Teaching Tool of the Rain Classroom

Rain classroom is jointly developed by the Online Education Office of Tsinghua University and Classroom Online [3]. It integrates complex information technology methods into our commonly used PowerPoint and WeChat to build bridges in all links before class, during class and after class, provide data support to the teaching process and coordinate the relationship between teaching and learning [4].

In terms of the curriculum design, we still adhere to the high requirements of the curriculum for students' practical operation, strive to have consistency before, during and after each class, consolidate the basic knowledge, improve the interaction of the practice stage, and prompt students to solve puzzles in time and learn with thinking.

1) Pre-class preparation period

Experimental and practical courses are carried out in combination with theoretical courses. In particular, practical courses involve multi-disciplinary knowledge points and require students to master solid basic theoretical knowledge. However, although the students have taken relevant courses, their mastery levels are not the same. Some students in the previous theoretical lessons only focused on the test sites and did not pay attention to non-exam content. Therefore, the preview work is particularly important in the teaching process of the course. Good preparation can consolidate the theoretical foundation of students, standardize the operation process of practical equipment, stimulate students' professional interest, and improve their self-confidence in the process of practice [5].

Rain classroom provides the function of pushing the courseware before class. Before the class, teachers can sort out the basic knowledge points related to this lesson and push the materials to students. And rain classroom also supports the preview courseware with videos. Appropriate short video materials will better help students enhance the perceptual understanding of the problem. In order to facilitate teachers to understand the effect of students' previewing, some test questions or survey questionnaires can be added after the previewing materials, which can enable teachers to grasp the students' previewing acquisition in time and lay a good foundation for the development of the classroom.

2) The interactive phase

In the practical course teaching based on the rain classroom, the teacher projects the classroom QR code onto the screen before class, and the students can enter the classroom by scanning the QR code through their mobile phones. There is no need to manually sign in or waste time to call the roll. Rain classroom also has the function of courseware synchronization. The PPT screening on the teacher's side can be synchronized to the student's mobile phone. If the teacher turns on the function of live teaching, it will be synchronized to the student's side together with the teacher's voice. This function has also been widely used in Online teaching during the epidemic. In this way, students don't have to take notes in a hurry during the lesson, so they can have more time to follow the teacher's explanations to think. For the parts that they don't understand temporarily, they can click "Don't understand" under the courseware, and for the key courseware, they can click "collection".

For practical courses, we spend less time explaining the principle part, and focus more on the operation process of students' real hands-on practice, the emphasis on matters needing attention, and the guidance in the practice process. We have sorted out the issues that have been more problematic in the classroom in the past years. Before the hands-on practice, the teacher will no longer emphasize them repeatedly, but will instead describe the malfunctions or errors, which directly drives the students to do the pre-hands-on discussion. Students can raise their hands to answer the questions, or the teacher can randomly call names in the Rain Classroom to ask students to analyze. In this way, students have a deeper understanding of the problem than the teacher’s mere repetition, and it also enlivens the classroom atmosphere. Students are willing to express their own views, even if the answer is wrong, there will be other students to refute or question.

3) Feedback and summary stage after class

After practice classes, we used to ask students to submit a report to summarize the practice process. Then, the teacher gives a score according to the completeness of the report and the completion of the practice. In fact, students will have some gains and lessons in practical courses, and they are also willing to share them, or some students want to make some suggestions for improvement of the teacher's classroom based on their own circumstances, and now the rain classroom has provided teachers and students with such a platform for after-school contact. Teachers get students' knowledge acquisition in time through survey and voting activities, and students give suggestions back to teachers through contributions, so that teachers can summarize and improve classroom teaching, and truly achieve the unity of teaching and learning. The practical report submitted on the rain classroom platform also supports the students to attach video display, which is more intuitive and comprehensive for the experimental phenomena.

With the help of the Rain Classroom platform, teachers can also calculate the simulation data and parameter adjustment data involved in the experiment, which helps to make an objective analysis of the overall acquisition of the students. We can also make a comparative analysis of the acquisition of the students of the previous and subsequent classes, quantify the learning effect of the students, and provide an objective reference for the teaching process.

2.2 Integrating the Effective Teaching Methods of O_AMAS

Nankai University has always attached great importance to undergraduate teaching. The O-AMAS effective teaching model was put forward by the effective teaching team of Nankai University in 2017. It is an effective teaching model with learning objectives as the guidance, benign interaction between teachers and students as the core, promoting teachers' effective guidance, students' active learning and deep learning. As shown in Figure 1, the idea of o-amas teaching design mainly consists of five parts: Objective (O), Activation (A), Multi learning (M), Assessment (A) and Summary (S) [6][7].

1) Teaching objective design

The effective teaching model of O-AMAS mainly adopts the idea of OBE teaching design. The design of teaching objectives is required to conform to the " SMART " principle, that is, the teaching objectives are specific, measurable, achievable, realistic and timely. The teaching objectives of experimental and practical courses are designed to achieve the high-level goals of practical education, that is, students should have the ability to apply, analyze, synthesize and evaluate knowledge. Appropriately increase the difficulty and depth in the experimental practice courses to improve the students' academic challenges.

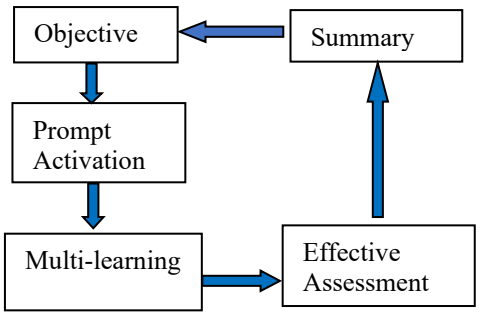

Fig. 1. O-AMAS effective teaching model

2) Rapid activation

The problem-driven teaching method is integrated into the experimental and practical teaching. Although the theoretical knowledge points in the curriculum are abstract, they have a strong application background. In the teaching process, we combine important concepts or theories with application examples to stimulate students' interest in learning and enable students to quickly enter the classroom. For example, we use the magnetic levitation theory to understand the magnetic levitation train and wind tunnel magnetic levitation system in the real world and

use the bamboo dragonfly to understand the UAV. This way makes the classroom more vivid and interesting, which is conducive to students to master relevant knowledge.

3) Multi-learning

In the experimental practice teaching, it is suitable to teach in the form of group learning, while the traditional direct teaching method is not suitable. Cooperative Teaching, Peer Teaching, Problem-based Teaching and Project-based Teaching are used interspersed to guide students to be familiar with and master relevant theoretical knowledge from different levels and angles. According to the actual problems encountered, the teaching content is optimized, and a complete teaching link and structure are designed. The introduction of scientific research questions related to the major direction as the curriculum design will make students grasp some important knowledge more systematically and deeply.

4) Effective assessment and feedback

The commonly used effective evaluation methods include: ①visual representation ②oral representation ③writing mode ④large-scale projects or performance. In the process of experiment and practice, we should pay attention to the effective evaluation of students' theory, operation, phenomenon analysis and so on, which will help students better understand their own learning situation, and at the same time, help teachers make adjustments based on the results of the evaluation. From the perspective of long-term talent training, this way is more conducive to developing students' awareness and ability of sustainable learning.

5) Summary

At the end of each course, the teacher will lead the students to make a brief summary of the class, distinguish the important information and non-important information in the course, help the students to clarify their ideas, sort out the key points, cooperating with the methods of "ticket" and "flying flag", so that the students can better grasp the knowledge. We can also use the difficult points in the course as thinking questions, leaving them open for discussion in the next class. And, at the end of a large practical project, students can use mind map to summarize the knowledge. These methods help students review and summarize the overall knowledge.

2.3 Improving the Evaluation Mechanism

Aiming at the shortcomings of previous practice projects that focus on the results and ignore the process, and focus on explicit behaviors and ignore implicit inner activities, this project adopts the Delphi Method and the Hierarchical Analysis Method (AHP Method) to construct a comprehensive competence evaluation mechanism.

The Delphi Method refers to the method of consulting experts extensively in the form of a written questionnaire for group decision-making [8] [9]. In this study, the Telfer method is used to screen the basic elements of the comprehensive competence evaluation system, which is to be carried out according to the following steps: designing the consultation form for the opinions of the indicators; selecting the experts and asking them to fill in the questionnaire; collating and feeding back the opinions of the experts and statistically analyzing the opinions; modifying the consultation questionnaire according to the results of the first round of consultation and transferring it to the second round of consultation activities; soliciting the

opinions of the experts in depth, determining the results of the relevant consultation, and reaching more consistent conclusions through about two or three rounds of consultation activities About 2 to 3 rounds of consulting activities to reach a more consistent conclusion.

Hierarchical analysis is a multi-objective or programmed decision-making method, combining qualitative and quantitative analysis thinking to make the decision-making process hierarchical and quantitative [10] [11]. Specifically, the decision problem is first decomposed into levels of objectives, criteria, and options, and then the priority weight of each element at each level over the element at the previous level is obtained by solving the eigenvectors of the judgement matrix, and then the final weight of each option over the overall objective is combined in a weighted sum. In this study, the hierarchical analysis method is used to construct the weight index system of the comprehensive capacity evaluation mechanism, as shown in the following steps:

1) Preliminary construction of hierarchical structure model:

After applying the Telfer method to screen the basic elements of the comprehensive ability evaluation system, the hierarchical structure model is constructed. The evaluation results of each evaluation target can be obtained by the following calculation formula:

$$V(0) = \sum_{i} w_i v(0_i) \tag{1}$$

Where, $V(0)$ indicates the final evaluation result of comprehensive ability evaluation, w indicates the evaluation index weight coefficient.

2) Judgement matrix construction:

Determine the weights between each factor at each level, compare each level of indicators two by two, compare the vertical column of factor indicators with the horizontal row of factor indicators one by one, and in accordance with the provisions of the following Table 1, depending on the degree of their importance, marked with the corresponding grade figures, to construct the judgement matrix of evaluation objectives A.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{2}$$

Table 1. Relative importance judgement scale

Relative importance	Meaning	Explanation
1	Equally important	Both factors are of equal value to the realization of the objective
3	Slightly important	One factor is slightly more important than the other.
5	Important	One factor is more important than the other

7	Very important	One factor is significantly more important than another factor
9	Absolutely important	One factor is significantly more important than another factor
2、4、6、8	The median of two neighboring degrees	-----
The reciprocal of the above non-zero numbers	The value of the degree of insignificance corresponding to each of the above degrees of significance	If I is more important than J, I is more important than J, which is recorded as 5; while J is more important than I, which is recorded as 1/5.

3) Normalization of the elements of the judgment matrix:

The general term of its normalized elements is: $A_{IJ} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}$,where, (i,j=1,2,3 ..... n), a_{ij} is the original data.

4) Weight vector solving:

$$W_I = \frac{w_i}{\sum_{j=1}^{n} w_j}, \quad \text{i=1,2,3…} n \ldots \tag{3}$$

5) Weight coefficient calculation:

Using the weight calculation formula 4, the weights determined for each evaluation indicator in each layer are calculated separately, and the average value of the weights is calculated, so that a collection of weight coefficients of the indicators of the evaluation system recognized by the majority of experts can be obtained.

$$w_i = \frac{1}{n} \sum_{j=1}^{n} \left(\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \right) \tag{4}$$

6) Verify the consistency of weight coefficients:

First, calculate the maximum eigenvalue of the expert judgment matrix: $\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{n w_i}$, where $(AW)_i$ represents the i elements of the vector AW ; Calculate the consistency index value CI based on the formula $CI = \frac{\lambda_{\max} - n}{n-1}$; According to the order value n of the matrix, search for the corresponding random consistency variable (Table 2) to obtain the value of the random consistency variable RI; Calculate the ratio of consistency indicators to random consistency variables, that is, the random ratio $CR = \frac{CI}{RI}$. When the random ratio is reached $CR < 0.1$, it can be considered to have reached a compatibility level. The weight coefficients

of the indicators determined by experts have good consistency. If $CR > 0.1$, it is recommended to revise the weights of the indicators.

Table 2. Table of Random Consistency Variables

n	1	2	3	4	5
RI	0.00	0.00	0.58	0.90	1.12
n	6	7	8	9	10
RI	1.24	1.32	1.41	1.45	1.49

3 The effects of the reforms

Through the above reform measures, teachers broaden their horizons by participating in teacher training and various academic seminars, have a full understanding of the advantages and disadvantages of the courses themselves, broaden their teaching ideas, and are active in experimental teaching reforms and self-made experimental equipment projects. Participated and published relevant teaching reform papers in core journals, and achieved good results in self-made equipment competitions and teaching competitions.

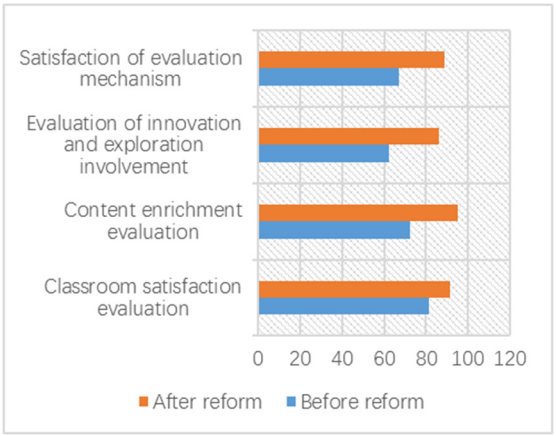

Fig. 2. Comparison of course satisfaction before and after reform

In Nankai University's Teaching Management Information System, students will give relevant evaluations to the courses when they check their course scores, and the evaluation results will be displayed on the teacher's side as a statistical satisfaction percentage [12]. As shown in Figure 2, comparing before and after the curriculum reform, this paper makes a chart comparison from four aspects: the satisfaction of practice class, the satisfaction of curriculum content enrichment, the satisfaction of curriculum innovation and exploration, and the satisfaction of curriculum evaluation mechanism. It is obvious that our curriculum reform has been recognized by most students, and the overall satisfaction of the classroom has been greatly improved.

4 Conclusion

The College of Artificial Intelligence attaches great importance to experimental and practical courses, which play an important role in the construction of National first-class courses. Through the above exploration and Reform in classroom form, curriculum content and evaluation methods, students' interest in learning has been enhanced, and an effective classroom with "content in classroom, participation of teachers and students, interaction in form and evaluation in standard" has been initially built. Of course, in order to build the experimental and practical courses into the first-class courses, the teaching and research group should continue to work hard, take the students as the center, listen to the suggestions from all sides, make full investigation and research, and continue to improve.

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