BOPPPS Classroom Teaching Design in the "Negative Feedback Closed-Loop Control System" Lesson

Qin Zhang(✉)

School of Logistics Engineering, Shanghai Maritime University, Shanghai 201306, China
qinzhang@shmtu.edu.cn

Abstract. Persist in the basic mission of cultivating people with virtue, take new engineering construction as the leading, focus on classroom teaching innovation, this paper puts forward the BOPPPS classroom teaching design based on SMART teaching objectives and participatory learning. Firstly, the attention curves of students in the classroom were analyzed, and the book-style BOPPPS strategy which enhances students' interactive was adopted; then, the meaning and design criteria of the six links of BOPPPS were described in detail, and the SMART writing format of teaching objectives and participatory learning arrangement were focused on; finally, taking the classroom of "Negative Feedback Closed-Loop Control System" as an example, the specific methodology of BOPPPS classroom teaching design was specifically illustrated. The results show that BOPPPS classroom teaching can make students participate deeply in the classroom learning, effectively improve the phenomenon of attention dispersion, and enhance higher-level abilities.

Keywords: new engineering · BOPPPS · teaching objectives · participatory learning · classroom design

1 Introduction

"China's Education Modernization 2035" emphasizes adhering to the fundamental task of developing moral character and talent and guiding by the concept of constructing "New Engineering sciences", focusing on innovation in teaching, guiding teachers to focus on teaching and education, and forming the value pursuit of excellent teaching and conscious actions.

Classroom teaching innovation models at home and abroad refer to the new and creative teaching methods, educational approaches and analysis models applied in the process of teaching. Such models are introduced by different countries and can be divided into institutional innovation and educational innovation. These two models are different in the degree of openness and innovation.

After comparing the effect of non-intervention and non-blended learning, Liu et al. (2016) found that blended learning was effective for healthcare professionals, and testing before-and-after research design and practice could improve the knowledge acquisition of medical care learners [1]. Adi et al. (2020) found that the combination of

C. F. Peng et al. (Eds.): EIMT 2023, AHSSEH 8, pp. 1023–1030, 2023.
https://doi.org/10.2991/978-94-6463-192-0_133

blended learning and Project-Based Learning (PBL) activities provides various learning resources to promote learning [2]. Ma et al. (2021) studied the BOPPPS teaching method and found that it could stimulate students' enthusiasm and interest [4]. Yang (2019) designed the teaching content of the "College Computer Basics" course according to the six-stage basic structure of the BOPPPS model, from which teacher can center on students and transfer passive learning to active learning, and effectively cultivate students' autonomous learning capabilities [5]. Tao et al. (2020) adopted the BOPPPS model to design the "Multi-rate Digital Signal Processing" classroom teaching, improving the quality of teaching design and stimulating students' learning initiative [6]. Xie et al. (2021) integrated the two teaching models of "BOPPPS" and "PBL", promoted the teaching from "classroom" to "classroom and outside", strengthened students' learning initiative, and achieved the organic integration of professional education and application-oriented personnel training, maximizing the teaching effect [7]. Zheng and Ma (2021) verified that BOPPPS can promote students' real participation in classroom teaching under online teaching situations, and it was a better participatory teaching practice strategy for improving teaching quality [8].

2 Classroom Teaching Innovative Model Analysis

The teaching concept is set up with taking the student development as center, introducing new engineering and the combination of production, teaching and research, carrying out the stratified and guidance teaching process. The aim is to realize the teaching goals of knowledge guidance, ability cultivation and quality training for students. Among them, the classroom teaching innovation model which encourages students' learning initiative and promotes the students' deeply participation of the whole teaching process is the key.

The attention curves in Fig. 1 show that students' attention gradually decreased from a high level of concentration in the traditional classroom learning, and 2/3 of 45 min was in a low concentration phase, resulting in students not being able to grasp classroom knowledge and effective manner. Therefore, in order to improve students' attention to the classroom, a shelf strategy should be adopted [9], as shown by the solid line in Fig. 1. By interweaving teaching and student-initiated learning strategies, the interaction between teachers and students is enhanced, promoting students' active participation in classroom activities. And one of the effective shelf strategies is BOPPPS.

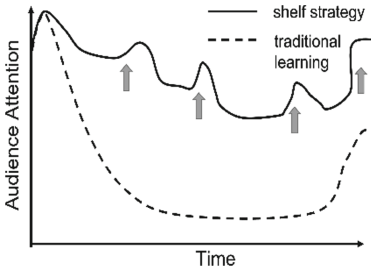

Fig. 1. Student attention curve in class

The philosophy of BOPPPS is learner-centered. By stressing the active participation of learners and constantly stimulating their enthusiasm for learning, the leaner can truly become masters of self-learning. BOPPPS teaching model has strong adaptability and operability for different subjects. This paper designs the BOPPPS teaching model for the compulsory professional course "Automation Instrumentation and Process Control" of the electrical system.

3 BOPPPS Design for "Negative Feedback Closed-Loop Control System"

BOPPPS stands for the initials of the six stages: Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, and Summary. All of them make a complete and effective classroom teaching process, and each stage serves the purpose of achieving the educational objectives.

1) Bridge-in

The purpose of the introduction is to ignite students' interest in learning. Its function is to improve students' attention in teaching activities and highlight the correlation between course content and students, so that the content of the class can become an applied skill. The forms of introduction are various, such as, audio and video related to the topic of the course, or questions related to facts and life, or knowledge connection with the content that has been learned or will be learned in the future.

For example, in the lesson of "Negative Feedback Closed-Loop Control System", the video of the Jiaolong submersible was introduced. By introducing that Jiaolong is a manned submersible independently designed and integrated by our country, it created the record of the maximum diving depth of the same type of submersible, which can hover and be correctly positioned at complex seabed such as ridges, ocean basins, basins and hydrothermal vents, providing reliable guarantees for deep sea mining, high-precision terrain measurement and deep sea biological exploration. It can be seen that the position control of submersibles is very important. The depth control with the sea surface can collect the morphological forms of abyssal creatures, and the altitude control with the seabed can realize high-precision terrain measurements. How to realize accurate depth control and altitude control? Raising the question to stimulate students' interest.

2) Objective

The learning objective is to make it clear what students will gain at the end of the class that is measurable or observable. The outcome-oriented performance test with learning objectives as its core is the final landing point of BOPPPS classroom teaching, the whole class is mainly induced by classroom questions, and the core is the participatory interaction between teachers and students around the problem solving [10].

SMART principle is used to draft high order learning objectives in this paper. SMART (Specific, Measurable, Attainable, Relevant, and Timely and time-bound) is proposed by management guru Drucker and widely applied in enterprise management, performance management and formulation of teaching objectives. Firstly, objectives should be specific so that both teachers and students have a clear understanding. Then the objectives can be observed and measurable by teachers. Third, the objectives can be attained through the effort of students with due respect for different needs and discrepancy. And students can

comprehend its value from its relevant. At last, teacher should certain the time to achieve the objective by Timely and time-bound, so that students can work on tasks within a given timeframe.

There are three teaching objectives of the "Negative Feedback Closed-Loop System": 1. Through this lesson, everyone can clearly recite the definition of the closed-loop control system; 2. In the class, everyone can design an accurate closed-loop position control system; 3. After class, by inspecting the deviation change, the team can analyze the control process of the negative feedback closed-loop system completely and apply it to the altitude and depth control of the submarine.

3) Pre-assessment

There are all kinds of pre-assessments. Single person or small group can do true or false, selection, Q&A, mind map, etc.

The pre-assessment in the "Negative Feedback Closed-Loop System" is a PBL task assigned by the online course. The groups searched for the application fields of the resistive pressure sensor and drew a mind map. Through the PBL team tasks, students can gain confidence after sufficient searching and sharing of information, at the same time can arouse the knowledge base of other students and think of ways to improve. In this way, the teachers can understand the students' mastery level of the online knowledge, whether the students are interested in the differential pressure gauge. And then teachers throw out the question "how does the Jiaolong use the pressure sensor to detect the depth of the underwater for the position control? And how to control the location in the deep sea?".

4) Participatory Learning

Participatory learning is the most time-consuming step in the classroom. According to the survey research of National Training Laboratory of USA, passive learning includes listening, reading, audition and demonstration, while active learning includes discussion, practice, and teaching others. Although the teaching by passive learning is more efficient in knowledge transmission, it can be seen from the learning pyramid that the retention rate of active learning is much higher than that of passive learning, so active learning has better effect on higher-level cognition.

The participatory learning form in "Negative Feedback Closed-Loop Control System" includes: lecture learning, group discussion, deep learning, role play of group discussion and deep learning. Firstly, it starts from the sensor and control chip to lecture the design ideas of Jiaolong submersible position control system. When the anti-interference ability of the position open loop system is poor and cannot realize the precise control of the position, how to improve the control system? And then teacher introduce the concept of closed-loop control system to guide students to think about how to calculate the deviation to form a negative feedback control system. Through group design of underwater position closed-loop control system, role playing the four elements of closed-loop control and analyzing the control process, fully interactive participation allows students to get deeply involved in teaching. Finally, the control effect is verified by software Simulink's simulation and compared with the open-loop system to meet the purpose of practice is the only criterion for testing truth.

5) Post-assessment

The post- assessment content includes two parts: 1. Basic knowledge and understanding, which can be assessed through multiple choice, judgement, pairing, filling in blanks, short answer and so on, which is counted by XueXiTong; 2. Proficient application or analysis of cases.

In the "Negative Feedback Closed-Loop Control System" class, students learned to design and analyze the depth control system of the Jiaolong. After that, teacher tested the students' ideas and processes of designing the altitude control system of Jiaolong, and checked whether the students could master and apply the principles and analysis of closed-loop control system skillfully.

6) Summary

Teachers and students work together to summarize the key and difficult points of this lesson and reflect again on whether the learning goals have been achieved.

In the "Negative Feedback Closed-Loop Control System" lesson, students have learnt three contents: 1. Open loop control can be used to achieve position control, but cannot achieve precise control; 2. Explaining the concept of closed-loop control system and designing closed-loop position control system; 3. Analyzing the control process of negative feedback closed-loop system and controlling according to the deviation to eliminate deviation and reach the expected value.

At last, all of the students know that the position control of the submarine is very important for the scientific research. And now the Fighter successfully had sat at the bottom of the Mariana Trench at a depth of 10909 m, which had achieved the international maximum submersion depth, representing the further promotion of our country's deep-sea equipment system's independent innovation.

4 Teaching Effect

BOOPPS organization of teaching design in each face-to-face class of "Automation Instrumentation and Process Control" as show in Fig. 2.

In the first 1 min, teacher bridges in engineering applications, academic hotspots, social needs, etc., such as the location control system design of deep-sea diving, the design of the control system of auxiliary robots, etc. In the 0.5 min, teacher sets learning objectives: learning the theoretical methods and application examples, mastering the deduction process of control theory and the structural principles of instruments and meters, and being able to design a control scheme to solve the problem. For the next 4.5 min, teacher gives the pre-assessment to understand the students' online learning situation and link the group PBL homework of the last lesson. For the 33 min, teacher work hard to interest all students to participate in the learning, through throwing out questions to trigger students' thinking and group discussion, answering questions through case analysis, further putting forward questions to help students deeply transfer learning, and sharing and analyzing the problems through role play, programming simulation and flipped classroom. In the 2 min, teacher uses post-assessment to test the learning results of students and whether the learning objectives are achieved. In the last 4 min, students summary the content and scientific research methods, all the people discuss the

domestication of production equipment and mission of technological rejuvenation of the country.

Since 2018, BOPPPS classroom teaching design has been implemented in the course of "Automatic Instrumentation and Process Control" in senior grades of electrical engineering department. The comparison of assessment results in four semesters is shown in Fig. 3. The proportion of failed students has decreased significantly, and the proportion of passing, medium and good students has increased, especially the excellent rate of 2021 has reached 21%. It can be seen that the teaching objectives have been achieved by adopting BOPPPS classroom teaching design, and students' understanding, mastery and application of knowledge can be effectively improved.

The feedback statistics of Table 1 further illustrates the good effect of BOPPPS classroom strategy. 92.31% of the students agreed that the class was student-centered, 84.62% of the students reflected that the student interaction modes in the class were various, and the teacher could allocate time reasonably for theoretical explanation and

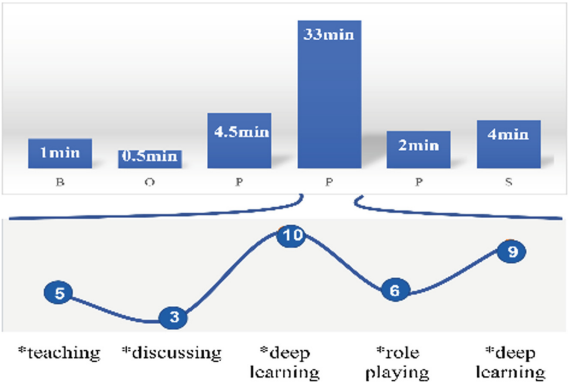

Fig. 2. Teaching design with BOPPPS

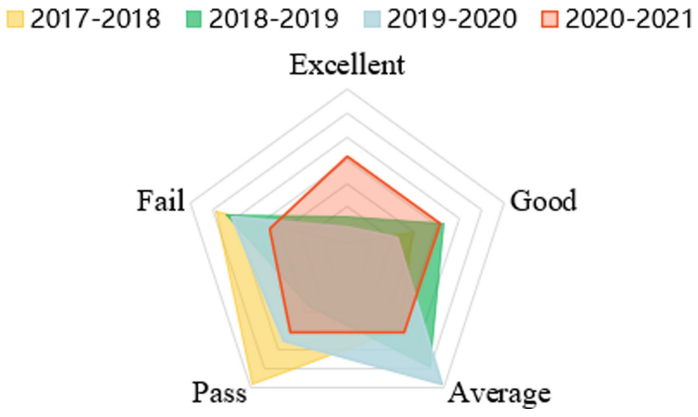

Fig. 3. Comparison of the results

Table 1. Students' feedback for the BOPPPS classroom teaching

Contents	Evaluation			
	Often (%)	Occasionally (%)	Generally (%)	No (%)
Learning centered around students	92.31	7.69	0	0
Interact with students.	84.62	15.38	0	0
Diversified learning modes	76.13	23.87	0	0
Reasonable ratio between theory and practice	84.62	15.38	0	0
Emphasizing and resolving difficulties	53.85	46.15	0	0
Inspire creativity and innovation	69.23	15.38	15.38	0

practical analysis. Half of the students also hope that the teacher can better highlight the key points and solve the difficult points in order to comprehensively improve the students' innovation ability. It can be seen that students have a higher understanding of problem thinking and improving their own ability, and they also put forward higher requirements for the teacher.

5 Conclusion

Take "Negative Feedback Closed-Loop Control System" classroom teaching as an example, taking the construction of new engineering to stimulate students' learning initiative as the innovation goal, the BOPPPS classroom innovation design is detailed described. It specially highlights the design in teaching objectives and participatory learning parts. The SMART principles are adopted to write the teaching objectives, which enables students to clarify the specific learning objectives and completion rate under the time and other conditions. In the participatory learning of about 30 min, the teacher fully mobilizes the students' enthusiasm for participating in the classroom, constantly improving their attention and promoting the students to think constantly, and eventually solving the problems and achieving the teaching objectives of the knowledge guiding, ability shaping and quality training of students.

References

1. Liu Q et al. The Effectiveness of Blended Learning in Health Professions: Systematic Review and Meta-Analysis[J]. Journal of Medical Internet Research, 2016, 18(1): e2.
2. Abdillah A, Solihatin E, WRAMK. Needs Analysis of Blended Learning Development on Instructor Training at Basarnas[J]. Journal of Education Research and Evaluation, 2020, 4(4): 366.
3. Wang H, Xuan J, Liu L, et al. Problem-based learning and case-based learning in dental education[J]. Annals of Translational Medicine, 2021, 9(14): 1137-1137.
4. Ma X, Ma X, Li L, et al. Effect of blended learning with BOPPPS model on Chinese student outcomes and perceptions in an introduction course of health services management[J]. Advances in Physiology Education, 2021, 45(2): 409-417.

5. Yang J. Design of BOPPPS teaching method for “university computer foundation” course-taking understanding decimal and binary as an example[J]. Computer Engineering & Science, 2019, 41(S1): 178-181.
6. Tao D. et al. Classroom teaching design on “Multi-rate digital signal processing” based on BOPPPS model [J]. Experimental Technology and Management 2020, 37(7): 183-186.
7. Xie W. et al. A Study on the blended teaching model of BOPPPS and PBL [J]. Food Industry, 2019, 40(2): 230-233.
8. Zheng Yanlin, Ma Yun. Online participatory Teaching practice based on BOPPPS Model [J].Higher Education Exploration, 2021(10): 5–9.
9. Gibbs G. Preparing to teach: an introduction to effective teaching in higher education - Sydney Jones Library, University of Liverpool[EB/OL], 1992.
10. Xu Y J, et al. Research on the hybrid teaching mode of TCM based on the combination of BOPPPS and ChaoXing [J]. LISHIZHEN MEDICINE AND MATERIA MEDICA RESEAR,2019, 30(6): 1481-1482.