Applying PBL to the Online Teaching Under the Background of Informatization: A Case Study

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Abstract. This paper compares the influence of the PBL online teaching method and the traditional online teaching method on students' learning outcomes in three aspects, including students' participation in class, instructional mode, and teaching effectiveness. The present study utilized a case study method to analyze a case of online PBL physics class case in a university in Malaysia. The main findings in online courses are: (1) The participation of students in PBL courses is higher than that in traditional courses; (2) The PBL teaching method is student-centered and problem-oriented, leading students to work in small groups in various forms. While the traditional teaching method is mainly based on the teacher's lecture in a very single form; (3) The experimental data, in this case, shows that the PBL teaching method is more effective than the traditional teaching method. This paper illustrates the differences between the two teaching methods, along with explaining why the online PBL teaching method is more recommended. Besides, it encourages more teachers to delve into PBL and apply it to online courses better in the future.

Keywords: Problem-based learning · Online teaching · Teaching methods · Physics class case

1 Introduction

The PBL (Problem-Based Learning) teaching method, originating in North America and Europe in the 1970s, was primarily applied in clinical medicine and engineering to help students analyze and solve practical problems through problem-driven exploration of knowledge. Biggs indicates that PBL reflects the way people learn in real life, and they simply continue to use the resources available to them to solve the problems they are facing [1]. In the 21st century, PBL has been popularized and is widely used in education,

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becoming a highly respected teaching method. Unlike the traditional teaching method, PBL emphasizes projects as the main line, teachers as the main guide, and students as the main body [2]. PBL has changed from the passive mode of 'teacher speaks, students listen' to the active mode in which students are livelily involved [3]. The introduction of modern information technology, with the internet as its core, into the field of education has embraced further developments both in teaching structures and teaching modes. PBL online teaching has also become increasingly popular [4].

In 2020, the sudden emergence of the COVID-19 pandemic caused a great impact on the traditional face-to-face teaching mode. With the support of the Internet and modern educational technology, the world has made rapid responses and smoothly transitioned offline classes to online ones. As there was no precedent for large-scale online teaching before, teachers lacked experience. In the initial stage, online teaching just followed the traditional offline teaching method. Teachers used Tencent meeting, zoom, QQ group and other platforms to give live lectures or play recorded videos, which ensures the most basic classroom teaching links. However, through research and investigation, it is found that such teacher-centered teaching mode also has certain problems, such as students being easily distracted. Meanwhile, teachers cannot give feedback on students' reactions in time, resulting in low learning efficiency and poor teaching effect [5]. The PBL teaching method has shown great advantages in such an environment. Supported by modern information technology, it guides students to carry out problem-oriented learning in groups, cultivating students' ability to actively participate, cooperate and solve practical problems, which effectively enhances teaching efficiency [6]. This paper will review the two teaching methods in detail in the main body part.

2 Case Analysis

2.1 Background

Physics is a natural science subject that is closely related to life. It requires students to have a solid knowledge foundation, a strong logic system, and the ability to propose and solve problems in real situations, which coincides with the core requirements of PBL. Consequently, the characteristics of this subject make it possible to apply the PBL teaching method in online physics courses [7].

This paper will take the case study done by Fauziah Sulaiman at University Malaysia Sabah as an example to explore the advantages of PBL online courses over traditional online courses [8]. In order to test the effect of PBL online teaching and traditional online teaching, Fauziah selected 61 students majoring in physics and conducted experiments on the learning management system - Moodle. He divided them into the experimental group (30 students, attending the PBL online course) and the control group (31 people, attending the traditional online course). In addition, he set two important abilities, creativity and critical thinking, as the evaluation criteria to test learning achievements. The Torrance Test of Creativity Thinking (TTCT) and Watson Glaser Critical Thinking Appraisal (WGCTA) were used to get the scores of creative thinking and critical thinking of the two groups before and after learning. Based on the data results, it is concluded that the PBL online teaching method has more significant teaching effects than the traditional one.

2.2 Problems Existing in the Traditional Online Teaching Method

Under COVID-19, schools around the world are insisting on 'Suspension of offline classes without suspension of online learning', and the previously supplementary online courses have been transformed into the main teaching approach during the epidemic [9]. The traditional online courses are always set on professional online education platforms, with teachers giving lectures by sharing screens, playing audio and video and posting chapter tests on these platforms. Although this kind of teaching can basically keep the classroom running, it exposes the problem that online teaching is not as effective as it could be [10].

Students' Inactive Performance in Class
Students perform inactively in a traditional online class. There are a lot of courses based on practical cooperation in higher education institutions, but the sudden shift from offline to online courses has resulted in huge limitations in the teaching environment and space. The original process of practical interaction between teachers and students in the professional classroom is forced to be canceled. Students become passive recipients of the teacher's online one-way lecture, which has seriously weakened students' subjective initiative and sense of class experience [11]. Besides, the lack of a good learning environment for students who listen to lectures alone at home in front of a computer screen also makes them mentally slack and thus affects their ability to communicate and collaborate with others. In a questionnaire survey on the effectiveness of online teaching in 334 universities in China by the Online Teaching Research Group of the Teacher Development Centre of Xiamen University, the results of the technical services of the teaching platform show that students have raised higher demands in terms of immediacy of teacher-student interaction, which also indicates that students are eager for more engagement in online classes [5].

Single Teaching Form
The teaching effect is unsatisfactory in the traditional online teaching mode with a single form. For traditional online classes, teachers mostly teach and give feedback through live lectures, real-time interactive Question & Answer, and after-class assignments. The former two have high requirements on environment and Internet speed. Nevertheless, university students come from all over the country. There are some differences in internet speed and network signal in different regions, which influence the teaching effect [12]. Even if there is a video replay after class, many students are too lazy to rewatch it. As for homework, students usually pay more attention to the grade given by the teacher, rather than thinking about how to comprehend by analogy. Hence, it is very difficult for students to truly gain knowledge. What's worse, many students only cram for the exam, which does not actually improve their learning ability.

2.3 Advantages of the PBL Online Teaching Method

Student-centered Model
PBL takes students as the center of study. Fauziah Sulaiman believes that the traditional online class, where students listen and then complete the assignments by using referring

to examples or calculating, does not allow students to actively explore various ways to solve problems, nor can it guide students to connect their needs in real life with the knowledge learned in the class [8]. This kind of teaching is more like a didactic 'spoon feeding', which only makes students learn by rote and hinders their learning pace to a certain extent. On the contrary, PBL online requires students to come up with specific problems to be explored on their own, and then start collaborative, spontaneous and reflective learning. Moreover, with the help of modern information technology platforms, each member can communicate and discuss with the teacher and classmates online in time, so as to exchange ideas and achieve the same goal. The whole PBL online teaching process is student-centered, in which students complete many brainstorming with their classmates, forming divergent thinking and providing a variety of ideas for problem-solving. And the teacher only plays a leading role in it.

Multiple Teaching Forms

The teaching form of PBL online courses can be multiple. From Fauziah's experiment, it is obvious that on the premise of the same knowledge reserves, students from the traditional online group simply submitted their answers to the assignment as individuals, without any other exploration. Instead, students from the PBL online group were divided into small groups. In the beginning, they were given a series of physics-related questions about everyday life and assigned tasks through group discussions. And then each student tried to find out the best answers to the questions by searching the Internet, consulting the teacher, reading books and in every possible way. They can asynchronously post any ideas on the forum at any time, but they must enter the chat room once a week through the teaching system platform to share their views with their group members and express their support or doubts. During this learning period, there are always group leaders who continuously upload the latest information such as knowledge links, resources and notes related to the research problems so that other group members do not miss the point. And the above process lasts until the whole group has successfully solved all the questions. With practical problem solving as the goal of the course and the setting of an online forum and discussion room, the PBL learning process leads to a dramatic clash of ideas between group members. The students express themselves and have a stronger desire to convince others, looking for favorable arguments in more ways. Problem-based and collaborative group learning is superior to traditional learning that aims to complete assignments. In the process of collecting information, continuously thinking and outputting ideas, students' abilities can be greatly improved. Various forms of learning styles also keep students' minds in an active state.

Remarkable Teaching Effect

PBL online is highly effective in teaching and learning. Fauziah experimented for 16 weeks. The students' creative thinking and critical thinking tests were scored one week before and one week after the experiment to quantify the changes of effect before and after the traditional online learning and the PBL online learning. For creativity, he assessed it through the Torrence test of creative thinking (TTCT). The scoring criteria are divided into four items: fluency, flexibility, originality and elaboration. According to the results in Fig. 1, the test scores of the two groups were similar before the experiment, but after the experiment, the scores of the PBL group were significantly higher than

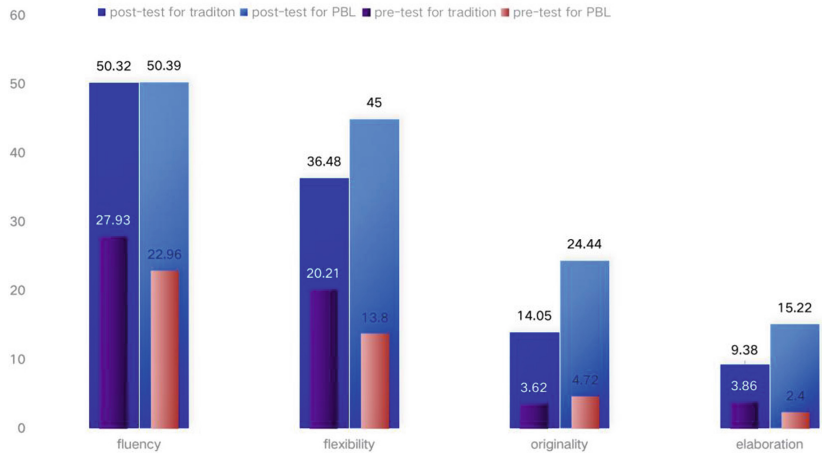

Fig. 1. Scores of creative thinking for the traditional group and the PBL group. (Photo credited: Original)

those of the traditional group. By comparing the differences in performance before and after the two groups of tests, it is clear that students made more progress after learning through the PBL teaching method. And after a statistical test by Mann-Whitney U test ($z = -2.13$, asymp. Sig (2-tailed) $= 0.03^* < 0.05$), it is found that PBL online learning has a significant effect on improving students' creativity. (The data in Fig. 1 and Fig. 2 comes from Fauziah, and the column charts are made by the authors.)

And for critical thinking, Fauziah assessed it by Watson Glaser Critical Thinking Appraisal (WGCTA), which is scored on five criteria: inference, assumption, deduction, interpretation and evaluation argument. From the results in Fig. 2, there was little difference in the scores between the two groups before the experiment. While after the experiment, the PBL group scored higher than the traditional group on all four indicators except assumption. Similar to the results of the creativity thinking test, students who went through PBL online learning made more progress. Again, Mann Whitney U test ($z = -2.16$, asymp. Sig (2 tailed) $= 0.03^* < 0.05$) was performed on the overall average scores of the two groups. It is found that PBL online learning has a significant effect on improving students' ability of critical thinking.

In summary, the PBL online learning method is indeed more effective than the traditional online learning method. With its 'student-centred' learning style, PBL online greatly promotes students' learning enthusiasm and allows them to develop their skills comprehensively.

2.4 Suggestions for the Traditional Online Courses

Nowadays, online courses have become an irreplaceable part of teaching and learning. How to improve the efficiency of online teaching and learning to achieve better results will be a topic that educators should keep exploring and studying for a long time in the future. In any discipline or field, the purpose of learning is inseparable from the

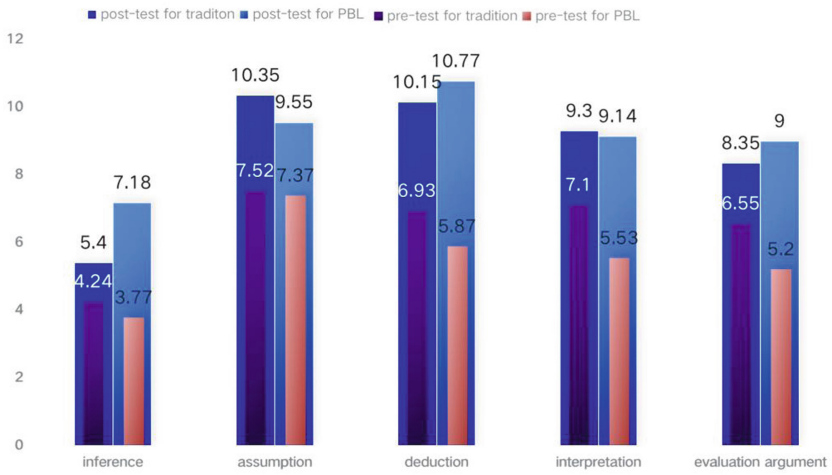

Fig. 2. Scores of critical thinking for the traditional group and the PBL group. (Photo credited: Original)

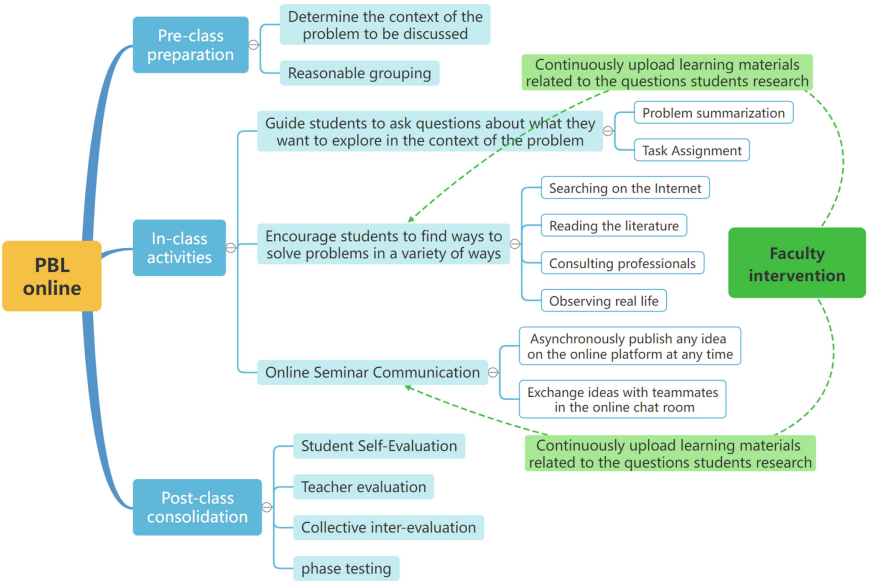

Fig. 3. Procedure of PBL online teaching. (Photo credited: Original)

four basic directions of 'mastering professional knowledge, improving personal ability, gaining competitive advantages and increasing optional opportunities'. Through the above case analysis, we do find that PBL online can help students achieve their goals more quickly. Therefore, we suggest that PBL should be integrated into teaching and learning as much as possible in today's higher education online courses, so as to enhance students'

subjective initiative in learning and help them develop their lifelong learning ability. The following Fig. 3 illustrates the specific process of teaching and learning, including three parts: pre-class preparation, in-class activities and post-class consolidation.

3 Conclusion

Overall, the PBL online teaching method has obvious advantages over the traditional one. PBL online teaching can encourage students to think actively and motivate them to study spontaneously. As an internet-based group discussion model, the PBL online teaching method allows students to participate in discussions in a variety of forms such as real-time chat and screen sharing. This teaching method creates a more conducive atmosphere for learning, and it can be used as a more regular mode of learning. What's more, it also helps students in higher education go ahead more quickly along their path of academic research and improve their skills in all aspects related to the courses. In turn, teachers can improve their teaching skills when designing courses and guiding students. Accordingly, PBL online is a win-win approach to teaching and learning, allowing teachers and students to make progress together. In PBL online students plan and complete a series of tasks to ultimately solve the existing problems, applying the knowledge to real practice. However, during the specific implementation of PBL online, it is also necessary to control every step and focus on every detail in order to get better results. At present, PBL online has already made some achievements, but there is still a lot of future work to be done to facilitate continuous improvements. PBL online can effectively mobilize the atmosphere of the class, which is well worth promoting and implementing.

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