The BOPPPS instructional model: development and implications for secondary science instruction

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Abstract: *After more than 40 years of development, BOPPPS has been proved to be a fruitful, efficient, and effective instructional model that promotes students' active participation in the classroom. The BOPPPS concept was born in Canada in the 1970s and has since through three stages: the improvement phase, the development phase, and BOPPPS in an educational informatisation environment. The research related to the BOPPPS model has three directions: procedural improvement, theoretical integration and environmental adaptation. We fully understand the significant value of the BOPPPS model for secondary school science teaching, and we improve the BOPPPS teaching model in accordance with the curriculum resources and students' circumstances in order to improve the quality of secondary school science teaching, drawing on the experience of applying the BOPPPS model in higher education and vocational education.*

Keywords: *BOPPPS; instructional model; secondary science instruction*

1. Introduction

BOPPPS is an instructional model with six procedures: Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment and Summary. Initially, the BOPPPS model was created as a lesson plan for the ISW (Instructional Skills Workshop) initiative in Canada, which was designed to prepare pre-service teachers. Instructional Skills Workshop (ISW) project in Canada for the preparation of pre-service teachers in the lesson plan[1], is an fruitful, efficient, and effective teaching model[2], teaching researchers in various fields of education are actively trying to promote active participation of students in the classroom through this mode of teaching and learning to better achieve the goals of teaching. Among them, secondary education is faced with young people who are developing rapidly physically and mentally. Secondary school teachers must consider how to develop the core qualities of young people of various ages, how to select effective teaching strategies, how to direct students to learn correctly and actively, and how to help them develop their own learning styles and cooperation abilities. While providing teachers with a framework structure to carry out pertinent instruction, a mature teaching model also allows teachers to make improvements to the model. What are the benefits of using the BOPPPS model in secondary education? What kind of skills do teachers need to develop? Can the BOPPPS model, which encourages active participation of students in the classroom and was initially used to develop the teaching skills of new teachers, be used in secondary education? Clarifying the BOPPPS model's components, the evolution of the historical lineage, the design of teaching and revelation, as well as other facets of the systematic analysis, is necessary to better know and understand the BOPPPS model, enrich the secondary school teaching model, and provide a reference for the theoretical research and teaching practice of the BOPPPS model.

2. Development of the BOPPPS model

2.1 Improvement phase (1979~2006)

The ISW project was developed in 1979 by Douglas Kerr's team under the direction of the Ministry of Advanced Education in British Columbia, Canada, with the goal of providing pre-service teachers in secondary schools with fundamental teaching skills. The ISW project's lesson plan is called BOPPPS. ISW documented the teacher training approach in a training manual, which was made available to the

pre-service teachers who took the training. At this point, the BOPPPS model was primarily used for ISW's teacher training and underwent internal development. Teachers were divided into small groups, and the trained teachers were asked to apply the BOPPPS model to a series of mini-classes, with the rest of the teachers and facilitators acting as participants and mentors, helping the trained teachers with their teaching and advising on classroom development.The ISW project was updated in 1982, 1989, 1993, and 2003[3], with five revisions. In 2006, the project completed its sixth internal update, and by this time, the ISW project had expanded somewhat, in terms of the target audience, with remedial classes not only for new teachers, but also for experienced teachers, and in terms of the platforms used to deliver the project, with the ISW gradually moving out of Canada and into the United States to some universities. At this stage, most of the research on the BOPPPS model was conducted within ISW, and much of it was distributed to participating teachers. The BOPPPS model is now considered to be more mature due to its support from theories such as Learning Styles Theory, Cooperative Learning Theory, Bloom's Classification of Educational Objectives, and others, as well as years of use in teacher training.

2.2 Development phase (2007~2020)

After the development of the improvement phase, the BOPPPS model has a clearly defined six processes (Figure 1).
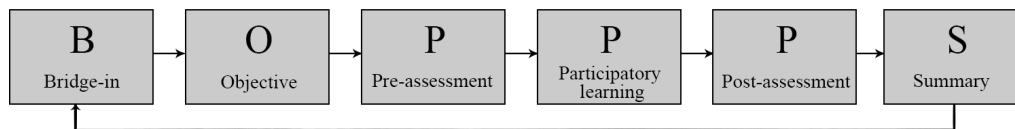

Figure 1: Structure of BOPPPS model

The first procedure, the bridge-in. This is the instructional procedure set up at the beginning of the class to focus students' attention and build a bridge to subsequent content. A good bridge-in builds on students' prior knowledge or life experiences and motivates them to learn by setting up problematic situations or describing the value of learning and focusing on what will happen in the classroom.

The second part of the process, the objective. Setting and making students clearly aware of specific learning objectives is an important part of the classroom. Depending on the content, teachers may choose to design different kinds of learning objectives. For specific knowledge content and skill levels, teachers can design objectives that are mainly declarative, observable and measurable Objective; for objectives that are not easily observable, such as emotional development, teachers can choose output-oriented, unobservable or poorly observable results that require students to use their knowledge to express Outcome. The design of the two kinds of objectives is not in opposition to each other, but is a combination of internal and external, you have me and I have you. Both objectives and outcomes are set up for the purpose of "teaching a good lesson", but the difference is that the objectives are the external growth of knowledge and skills, while the outcomes are the expression of students' emotions and values.

The third part, the pre-assessment, is to help teachers understand what is happening in the classroom. Teachers may benefit from pre-assessment in understanding the learning environment. Additionally, the pre-assessment may partially represent the variations in students' ability and knowledge levels. Recognizing these variations can assist teachers in modifying their lesson plans and the materials they give their pupils. Pre-assessment can assist teachers in carrying out interactive learning in a practical manner in this regard.

The fourth part is participatory learning. With specific learning goals in mind, the educated party actively and creatively intervenes in classroom teaching activities to help students learn, become more competent, and improve their work. This type of instruction is known as participatory teaching. Participatory learning is a teaching process that applies participatory teaching methods. The emphasis of constructivist-based participatory learning is on the active involvement of students in the learning activities that take place in the classroom, namely in the accomplishment of the teaching goals and the activities of deliberate development of their own knowledge systems.

The fifth part, the post-assessment. The purpose of the post-assessment is to gauge what the students have learnt and how they may apply it after engaging in interactive learning. Students will compare the learning objectives set in the objective session at the post-assessment stage to determine whether they have accomplished the objectives after engaging in the learning experience.

The summary is the sixth section. Summary is a procedure that lets students reflect on the knowledge and skills they have acquired during the learning process beyond the objectives in addition to reviewing what has been learned and defining the learning gains. Teachers, on the other hand, prepare the learning material for the following learning content by placing it after the summary part.

Researchers have started to conduct in-depth studies on the various aspects of the BOPPPS model.In 2009, Dean Giustini[4] introduced the concept of the BOPPPS model and emphasised the importance of participatory learning in the BOPPPS model. Cynthia Nemeth[5] highlighted the significance of pre-testing in the BOPPPS approach in 2014 by demonstrating how it increases the effectiveness of teaching and learning, concentrates students' attention, etc. SHi-Jer Lou[6] concluded that the BOPPPS model is effective in fostering students' creativity and collaborative learning through educational experiments. Ilka Wunderlich[7] studied bridge-in sessions in 2015 and came to the conclusion that they can improve teacher-student interaction by bringing teachers and students closer together. Ilka then suggested "student-student questioning," "mind mapping," and other techniques to carry out the bridge-in session. Yan Li[8] employed the BOPPPS technique in 2016 to instruct students in the speaking and writing of English. Students' communication, communicative, and cognitive skills can be effectively improved by active engagement in learning, according to English speaking and writing instruction, which is effective for teaching English. When considering the project's design in 2018, Gordon Stubley[9] noted that the prior instruction was overly concentrated on the strategy component, which hindered the improvement of the students' grasp of the lesson. Gordon emphasized that an important component of the BOPPPS model is that teachers may assist students in introducing, comprehending, and consolidating their information by using the BOPPPS objectives, pre-assessment, post-assessment, and summary sessions. In 2019, Huang Liang peng[10] applied the BOPPPS model to the teaching of the Principles of Visual Communication Design course, and found that the BOPPPS model can improve the students' interest in learning and the quality of students' homework.

During this period, researchers viewed BOPPPS as a relatively independent teaching model from ISW. These studies focused on the theory and practice of the BOPPPS model. In the theoretical studies, researchers mainly mined the theoretical foundation of the BOPPPS model and integrated some mature teaching theories with the BOPPPS model. For example, they used Bloom's objectives to design the objective session[11], and used mind maps to design the bridge-in session[7]. The researchers expect to improve BOPPPS so that the BOPPPS model can be better applied by teachers to achieve the teaching objectives. In terms of practical research, researchers no longer limit the application of the BOPPPS model to teacher skills training, but try to use the BOPPPS model in teaching in higher education, vocational education and even secondary education, where the BOPPPS model is used in teaching to develop students' oral English proficiency, information skills and so on. In these teachings, the recipients are not the same as the original recipients of the BOPPPS model, and the contents of the lectures have also changed a lot, so the main direction of the practical research of the BOPPPS model in terms of the curriculum resources and the recipients is to carry out the six parts of the model. For example, BOPPPS model can be used to design the reading class[12] and the mechanical laboratory platform construction class[13] and so on.

2.3 BOPPPS in an educational informatisation environment (2020~)

In January 2020, ISW published Network Description, which describes the ISW project's plans for teacher training in the Internet environment. Remote teaching has had a positive impact on the dissemination of the BOPPPS model, which has led to a significant increase in the number of studies that have been carried out to reflect on the BOPPPS model in an Internet-based environment after 2020. For example, in 2021, Fang qing Meng[14] based on the blended BOPPPS model of teaching on a database course pointed out that the blended BOPPPS model can increase students' interest in offline teaching with technical support and can assist teachers in teaching. In 2021, Yong fen Wu [15] used MOOC as a course resource platform, Rain Classroom as the delivery platform, combined with the BOPPPS model to teach a data structure course. Yong fen Wu pointed out that online teaching based on the BOPPPS model can effectively develop students' multiple higher cognitive abilities including analysis, evaluation, and creativity. In 2021, Shan Wang[16] improved the BOPPPS model by using SPOC teaching, and used it to teach an oral pathology course, and through interviews and questionnaires to investigate the effectiveness of the course implementation, it was concluded that the improved BOPPPS model was beneficial to the teaching of the oral pathology course.

At this time, the BOPPPS model was already a mature teaching model that had been tested in teaching practice and received good feedback. Researchers gradually began to try to improve the BOPPPS model according to the characteristics of the course, the teaching environment, and the

recipients, in order to better accomplish the teaching goals. With the development of information technology in education and the popularity of online delivery, researchers have used BOPPPS as an online delivery method to improve the pedagogical framework of remote teaching.

3. BOPPPS Model Development and Research in China

3.1 Introductory Phase (2007~2016)

In 2006, with the gradual maturation of the BOPPPS model, some Chinese scholars introduced the BOPPPS model into China by going to Canada for training, etc. In 2007, Huang Juan [17] introduced the ISW project in her article and pointed out that the BOPPPS model is the core of ISW. And the earlier, practical research on the BOPPPS model in China appeared in 2011.In 2011, Wang Ruo han[18] used the BOPPPS model in a course on plant reproductive ecology and found that the BOPPPS model had the characteristics of improving graduate students' learning interest and better teaching effect in graduate education. From 2011 to early 2016, Chinese researchers have mainly focused on the application of the BOPPPS model, mainly including the teaching effect of the BOPPPS model, teaching characteristics and the differences between the BOPPPS model and other teaching models. Within this period, researchers mainly carried out research on the BOPPPS model on teaching and learning in colleges and universities, and most of the subjects who were tested were students in colleges and universities.

3.2 Developmental Phase (2016~)

In February 2016, Cao Dan ping[19] elaborated the structure and theory of the BOPPPS model in detail in his published article after fieldwork and communication, and looked forward to the positive impact of the BOPPPS model on teaching in colleges and universities.In April, Zhang Jian xun[2] in Vocational and Technical Teaching, with the aim of effective teaching and learning, started from the theory of experiential learning and other theories on the BOPPPS model to elaborated and constructed an effective classroom teaching design based on the BOPPPS model. The above two articles had a profound impact on the research of BOPPPS model in China, and since then, the practical research of BOPPPS model has gradually changed from graduate students, undergraduates to senior students to secondary school students in terms of the target audience, and has gradually changed from mostly meso-study to micro-study in terms of the level of research.
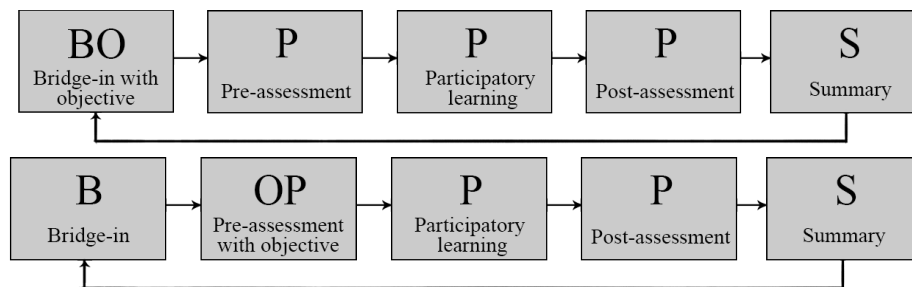

Figure 2: Structure of BOPPPS-like models

Throughout the evolution and development of the BOPPPS model, the research on the BOPPPS model is mainly reflected in the three aspects of procedural improvement, theoretical integration and environmental adaptation. Procedural improvement refers to changes in the implementation procedures of the BOPPPS model to adapt it to target instruction. There are fewer studies in this area, such as the BOPPPS-like models [20](Figure 2).

Theoretical integration refers to the research approach of generating new teaching strategies internally based on the BOPPPS model by incorporating new sociological, psychological, communication and pedagogical theories, etc., to achieve the teaching goals with the help of the implementation procedures of BOPPPS. For example, it is combined with interactive teaching theory [21], with effective teaching [2], with SIOP theory to form a teaching quality monitoring system[22], and with teaching methods such as PDG[23]. Environmental adaptation, on the other hand, refers to the targeted improvement of the BOPPPS model according to the changes in teaching methods or targets. Studies in this area include, for example, the hybrid BOPPPS model in the Internet environment [24] and the BOPPPS model in teaching in ethnic colleges and universities [25]. Looking at the

development trend of the BOPPPS model from the aspect of researchers, it can be found that the number of researchers in China has gradually increased, reflecting the rising development trend of the BOPPPS model in China; from the perspective of the research background, the BOPPPS model has been gradually enriched by the support of the Internet and the means of intelligent education; from the perspective of the target audience, the target audience has been gradually expanded from undergraduates to secondary and above education recipients. It can be seen that the research on the BOPPPS model is in the stage of diversified development, and the diversity of its research is profoundly affecting secondary school teaching.

4. Implications of the BOPPPS model for secondary science teaching

The BOPPPS model has been developed to a certain extent in China's higher education and vocational education teaching, and there have been many practical results. According to the current situation of secondary school science education, drawing on the research results of the BOPPPS model in teaching in higher education and vocational education, it is necessary to introduce the BOPPPS model and carry out systematic theoretical research and innovative practical exploration in terms of the teaching model in science education teaching.

4.1 Fully recognise the important value of the BOPPPS model for science teaching and learning

The application of BOPPPS teaching mode to carry out teaching has several advantages over the use of other teaching modes: firstly, it can cultivate students' advanced thinking skills, including analysis, synthesis, evaluation and creativity, etc.; secondly, it can promote students' participation in the classroom, focusing on the increase in the proportion of students' classroom discourse, the increase in the proportion of students' active questioning, the increase in the proportion of active silence time in the classroom, etc.; thirdly, it can develop students' co-operative learning skills, which is because the BOPPPS teaching model includes participatory learning design. In science teaching, the goal is not only for students to construct knowledge on their own, but also to develop higher-order thinking skills such as interdisciplinary conceptualisation, analysis and creativity. Unlike traditional knowledge transfer, student-constructed knowledge teaching cannot be accomplished through teacher instruction alone. This is because the process of constructing knowledge is a process of encoding, processing and storing knowledge, and this process needs to be based on students' existing knowledge frameworks. This not only requires teachers to help students recall existing knowledge in class, but also to help students process new knowledge during teaching. For the development of students' higher-order thinking skills, teachers are required to arrange scenario setting, practice guidance, cooperative learning and other links to gradually help students develop higher-order thinking skills by leading them through various processes of learning. These two requirements pose a great challenge to teachers' teaching model. A teaching model that is appropriate to the teaching objectives not only reduces the pressure of teaching, but also gives teachers the space to adjust their teaching methods according to the students and curriculum resources. The essence of the BOPPPS model is a teaching model, which has the advantages of being easy to learn and easy to operate, and the several advantages of the model are perfectly suited to the needs of teaching science in secondary schools, and the method of carrying out the various aspects can be designed by teachers. The method of carrying out each section can be designed by the teacher. For example, in the teaching of "free-fall motion", we can design the process of students' experiments and students' reports, and adopt the teacher's counselling and flipped classroom to carry out participatory learning teaching activities, which helps students to construct the concept of the law of free-fall motion better through independent experiments. This helps students to better construct the concept of the law of motion of free fall through independent experiments.

4.2 Improvement of BOPPPS according to the characteristics of the curriculum and the student situation

The BOPPPS model is currently used in higher education teaching and teacher training for students and new teachers in higher education. Firstly, they are adults and secondly, they have secondary school experience. Secondary school students are less capable than this group. In terms of physical and mental development, the arithmetic thinking of secondary school students is gradually changing from concrete arithmetic thinking to formal arithmetic thinking or even logical arithmetic thinking. In terms of different stages, teachers' teaching methods need to be adjusted accordingly; in terms of learning ability, secondary school students' learning ability is weak, such as cooperative learning, discovery learning,

etc., which needs to be led and guided; in terms of the types of courses, the courses applying the BOPPPS model are no longer skills training, but science courses with stronger logic, life and objectivity. Therefore, if we want the BOPPPS model to be effectively implemented on the teaching of science in secondary schools, it is necessary for teachers to make certain changes to the BOPPPS model. Firstly, improvements can be made by starting with the procedures of the model. For example, when teaching with a lesson plan, the objectives and the pre-assessment can be combined into a "pre-assessment with objectives", which on the one hand saves time and on the other hand enables students to clearly understand the purpose of the pre-assessment. Secondly, the teaching environment can be improved. In science courses, there are some experiments that cannot be reproduced in the classroom, which is limited by the economic and time sacrifices involved in conducting the experiments. Similarly, it is not possible to examine all aspects of a student's life in pre-tests and post-tests. In this case, it is necessary to take into account the physical conditions and make slight changes in the way of teaching and testing. For example, the introduction of information technology platforms, playing experimental videos on the platform or the assessment of the test. Finally, improvements are made according to students' abilities. Students are developmental human beings, BOPPPS model in various aspects of the way to carry out, need to choose according to the situation of students. For instance, in the "free-fall motion" participatory learning sessions, the teacher can arrange for students to observe the learning process if it is determined through the pre-test that the students' experimental skills cannot yet reach the level of independent completion of all experiments; if it is determined that the students' experimental skills can reach the level of independent completion of all experiments, the teacher will primarily guide and assist the students to complete the experiments independently.

5. Conclusion

The BOPPPS model has gone through an improvement stage, a development stage of theoretical and practical research on the improvement of the six links within the BOPPPS model, and a stage of BOPPPS in an educational informatisation environment over the course of more than forty years. In China, the BOPPPS model has gone through changes in the introduction stage and the development stage. Throughout the research on the BOPPPS model, there are three main research directions, namely, the direction of procedural improvement, the direction of theoretical integration that incorporates other teaching theories to modify the BOPPPS model, and the direction of environmental adaptation that incorporates the teaching environment to modify the BOPPPS model. Because the BOPPPS model promotes students' active participation in the classroom, with the deepening of the research, the research on the BOPPPS model mainly shows the trend of diversified research directions, enriched research backgrounds, and enlarged research objects, which makes the BOPPPS model gradually appear in the science teaching in secondary schools. Applying the BOPPPS model in secondary school science teaching requires a clear understanding of the value of the BOPPPS model for students and teachers, as well as the need to improve and adjust the model according to curriculum resources and situation of students.

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