BOPPPS Teaching Design of *Functional Foods* Course and Incorporation of Research Cases

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Abstract This study took the teaching practice of food-related majors in Chengdu University, a representative applied institution in China, as an example. Aligning with the course characteristics and educational objectives of *Functional Foods*, it introduced the features of the BOPPPS teaching model and its implementation in course design. By incorporating research cases and presenting teaching examples, the steps and methods of BOPPPS-based teaching reform were explored while incorporating ideological and political elements into specialized instruction. This study provides insights and references for reforming other food-related courses and contributes to cultivating more food professionals with practical awareness and critical thinking.

Key words Functional food; BOPPPS; Ideological and political elements; Research case; Teaching design

DOI: 10. 19759/j. cnki. 2164 -4993. 2025. 04. 012

Functional Foods is a highly forward-looking and application-oriented specialized course in the field of food science. It aims to guide students in exploring the relationship between food and health while mastering key knowledge and skills in functional food design, development, and efficacy evaluation. However, traditional teaching methods face multiple challenges[1]. The interdisciplinary nature of the course content makes learning abstract and difficult to fully comprehend. Weak practical links limit students' opportunities to apply theoretical knowledge, restricting the development of practical skills and innovative thinking. Textbook content often lags behind real-world application, failing to keep pace with industry trends.

In recent years, the BOPPPS teaching model, as a student-centered, interactive and outcome-based advanced pedagogical approach, has gained widespread attention in higher education[2-3]. The BOPPPS model emphasizes student-centered learning, interactive teaching, and outcome orientation, and comprises six key phases: bridge-in, learning objectives, pre-assessment, participatory learning, post-assessment, and summary[4]. This framework enhances student engagement and initiative, facilitates knowledge internalization and application, and improves overall teaching effectiveness[5]. Incorporating research cases into teaching provides students with practical contexts, helps them understand abstract theoretical knowledge, and cultivates scientific thinking and innovation abilities. It exposes them to industry frontiers, laying a foundation for career development[6-7].

In this study, based on the teaching practices of food-related majors in Chengdu University, the *Functional Foods* course was selected as the research subject to explore innovative instructional designs using the BOPPPS teaching model. By incorporating research cases, this study outlined the implementation steps and methods of this model in the course, analyzed its advantages and effectiveness in enhancing students' learning outcomes, practical skills, and innovative thinking, and summarized the challenges and corresponding strategies in teaching practice. The study provides insights into the reform of food-related professional courses.

Instructional Design of *Functional Foods* Based on BOPPPS Model

Applying the BOPPPS model in the *Functional Foods* course begins with framing functional food development, efficacy evaluation, and safety assessment as "scientific questions". Using familiar health food examples assigned online or pre-class helps focus students' attention and stimulate learning interest. To address low student engagement, brief questions or case studies are used to spark curiosity and guide thinking. Through participatory learning, students explore functional factors and mechanisms of functional foods to address the "scientific questions" and complete course papers. The BOPPPS model enables full immersion in learning, facilitating knowledge internalization and improved outcomes. The model's practical application is demonstrates using "Functional Carbohydrates: Prebiotics" as an example (Fig. 1).

Bridge-in

A scenario is created to introduce the new lesson. The teacher uses the trending news topic "Prebiotic Chocolate: Is It a Marketing Gimmick?" to engage students. Key questions are raised: What component in "prebiotic chocolate" qualifies as a prebiotic? What are its functional effects? No conclusions are drawn at this stage, transitioning smoothly to the next section.

Teaching objectives

Based on the talent development program and course

Received: March 27, 2025 Accepted: May 29, 2025

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syllabus, the learning outcomes for this section are defined, and the learning objectives are formulated according to Bloom's Taxonomy of Educational Objectives and communicated to students. Knowledge objectives: Students will be able to accurately describe the definition and classification of prebiotics, as well as their mechanisms of action in functional foods, such as modulating gut microbiota and promoting host health. Competency objectives: ① Through case analysis and group discussions, students will be able to articulate the application value and health impacts of prebiotics in functional food development, thereby enhancing their independent thinking, communication, collaboration, and problem-solving skills. ② Through assignments and preparatory tasks, students will independently conduct literature research and design simple prebiotic functional food formulations, strengthening their self-directed learning and innovative design ability. Affective objectives: ① Students will recognize the positive effects of prebiotics, enhance their awareness of the scientific basis and safety of functional foods, and develop food safety consciousness and health concepts. ② Through learning about prebiotics, students will understand the contribution of food science to health improvement, and establish professional identity and career responsibility. ③ The teaching aims to stimulate students' interest in the field of functional foods, cultivate rigorous and truth-seeking scientific attitudes and innovative spirit, and encourage exploration of new functional food development and applications.

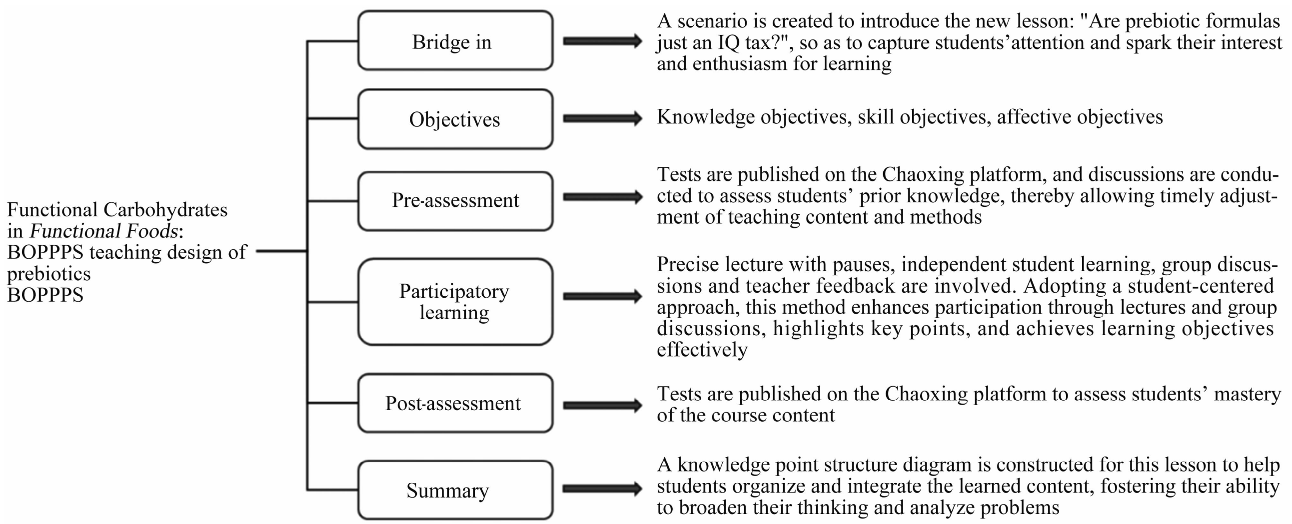

Fig. 1 Specific teaching design of *Functional Foods* course based on the BOPPPS model

Pre-assessment

Through pre-assessment, instructors can gauge students' learning interest and prior knowledge regarding the concept of "prebiotics". The instructor posts following questions on the ChaoXing platform: True/False Question 1: Prebiotics can be directly absorbed by the human body. True/False Question 2: All prebiotics function identically, and their intake can significantly improve gut health. Students answer based on their existing knowledge. The instructor adjusts the teaching content according to the feedback, reviewing or supplementing key points as needed, such as the composition of gut microbiota and the differences between prebiotics and probiotics. Instruction methods: Real-life examples such as yogurt and prebiotic dietary supplements are incorporated during explanations. Case-based and heuristic teaching approaches are adopted to guide students in reflecting on the applications and health impacts of prebiotics in daily life. This advances the instruction while strengthening students' professional identity with functional foods.

Participatory learning

This section consists of four parts: teacher-led explanation with pauses, independent student learning, group discussion, and teacher feedback. In the teacher-led explanation part, the definition and classification of prebiotics are introduced, with PPT animations illustrating their mechanism of action in regulating gut microbiota. Examples such as oligosaccharides in yogurt promoting the growth of beneficial bacteria are used to make abstract concepts more understandable. The teacher also reviews pre-class preparatory tasks to help students internalize the knowledge. During the independent student learning phase, the teacher assigns tasks requiring students to independently study the applications and health benefits of prebiotics in functional foods. Students are expected to research and document the formulations and mechanisms of action of two common prebiotics in functional foods, fostering their self-directed learning ability. In the group discussion phase, students work in groups, each including four students, to discuss: ① the advantages and challenges of using prebiotics in functional food development, and ② how to design and incorporate prebiotics to meet the health needs of specific populations (*e. g.*, the elderly, children, athletes). The "Highlights – Difficulties – Suggestions" learning method is adopted to facilitate knowledge exchange and refinement. After group discussions, a whole-class discussion follows. The teacher randomly selects 3 – 4 groups to share key insights or unresolved questions. The class is then invited to ask follow-up questions, with the teacher providing answers.

Post-assessment

In this step, students' learning outcomes are evaluated and feedback is provided. The teacher assigns tasks related to "prebiotics" via the ChaoXing platform: ① briefly explain the main physiological functions of fructooligosaccharides (FOS) as prebiotics and their application value in functional foods, and ② draw a schematic diagram illustrating how FOS functions in the human intestinal tract, and label key steps and action objects. These two tasks assess students' understanding of prebiotic concepts, mechanisms, and applications. Task 1 evaluates students' theoretical knowledge of prebiotic functions, while task 2 tests their comprehension and ability to articulate the process of prebiotic action, gauging their mastery of the lesson content.

Summary

The instructor guides students in constructing a knowledge map of the lesson to help them organize and integrate the learned content. Additionally, the instructor encourages students to reflect on and summarize the learning methodologies used in this session from a broader perspective. This approach helps expand their thinking and analyze fundamental issues, such as the diversity and complexity of prebiotics, safety and efficacy considerations, and interdisciplinary thinking.

Reflections on the Ideological and Political Design of BOPPPS Teaching Model in *Functional Foods*

In the implementation of the *Functional Foods* course, we adhere to a student-centered teaching philosophy that emphasizes task-driven learning, problem-solving as the core, and competency development as the goal. As a highly applied and life-relevant course, instruction should respect students' foundational knowledge, target their "zone of proximal development" and create authentic scenarios to stimulate learning interest and exploratory motivation, thereby fostering active knowledge construction. For instance, in the chapter of functional carbohydrates, we can integrate China's sugar industry development history (*e. g.*, sugarcane industry upgrading in Guangxi) to discuss its technological support for rural revitalization. We may also cite "sugar reduction action" policies (*e. g.*, "Healthy China 2030") to analyze their social responsibility in public health.

The course content covers multiple dimensions including ethics, laws and regulations, nutritional science, and health promotion, providing extensive opportunities for integrating ideological and political education[8-9]. In the teaching of functional food development and applications, students are guided to consider how scientific design and production processes can meet the health needs of diverse populations, while fostering professional identity and a sense of responsibility toward food safety and public health. From the perspective of functional food R&D, the course explores traditional dietary therapy culture and modern nutritional science, inspiring students' pride in traditional culture and patriotism. When studying development technologies, we expand their historical context and cutting-edge advancements to enhance students' comprehensive evaluation and analytical skills. Through analyzing typical cases in the field of functional foods, we guide students to explore safety and ethical issues, cultivate scientific thinking, elevate cognitive levels, and foster an innovative spirit to closely connect functional foods with human health and ecological sustainability.

Deep Integration of Research Cases

Research cases play a vital role in the curriculum reform of *Functional Foods*, as they can stimulate student interest, cultivate scientific thinking, and expand frontier knowledge of the discipline. Taking functional carbohydrates, which have both basic theoretical and practical value, as an example, the following is a teaching design that integrates scientific research cases.

Enhancing learning interest and classroom participation

Prebiotic oligosaccharides, as a key focus in current functional carbohydrate food research, can effectively stimulate students' learning enthusiasm through relevant scientific cases. Taking human milk oligosaccharides (HMOs) in infant formula as an example, we examined the novel relationship between HMO-utilizing bifidobacteria, aromatic lactic acid production and early-life immune modulation (Fig. 2). This discovery may explain previously observed phenomena, the negative correlation between bifidobacteria abundance in infant gut and the incidence of asthma/allergic diseases. Aromatic lactic acids potentially serve as key mediators for the beneficial immune effects induced by HMO-utilizing bifidobacteria. Classroom participation was significantly enhanced by helping students understand the mechanism of action of HMOs and exploring their potential for development in specialty foods.

Cultivating research thinking and innovation ability

Through analyzing and studying research cases, students can develop essential scientific skills including information collection, experimental design, data processing, and results interpretation. This process sharpens their scientific thinking, enhances research literacy, and strengthens practical problem-solving ability. For example, when explaining the dose-effect relationship of fructooligosaccharides (FOS), students worked in groups to analyze data on the impact of different dosages (2, 5, 10 g/d) on adult gut microbiota. They discussed the nonlinear relationship between short-chain fatty acid production and FOS dosage, and then designed optimized dosing protocols. Students master systematic research methods from data interpretation to experimental design by simulating the complete research process.

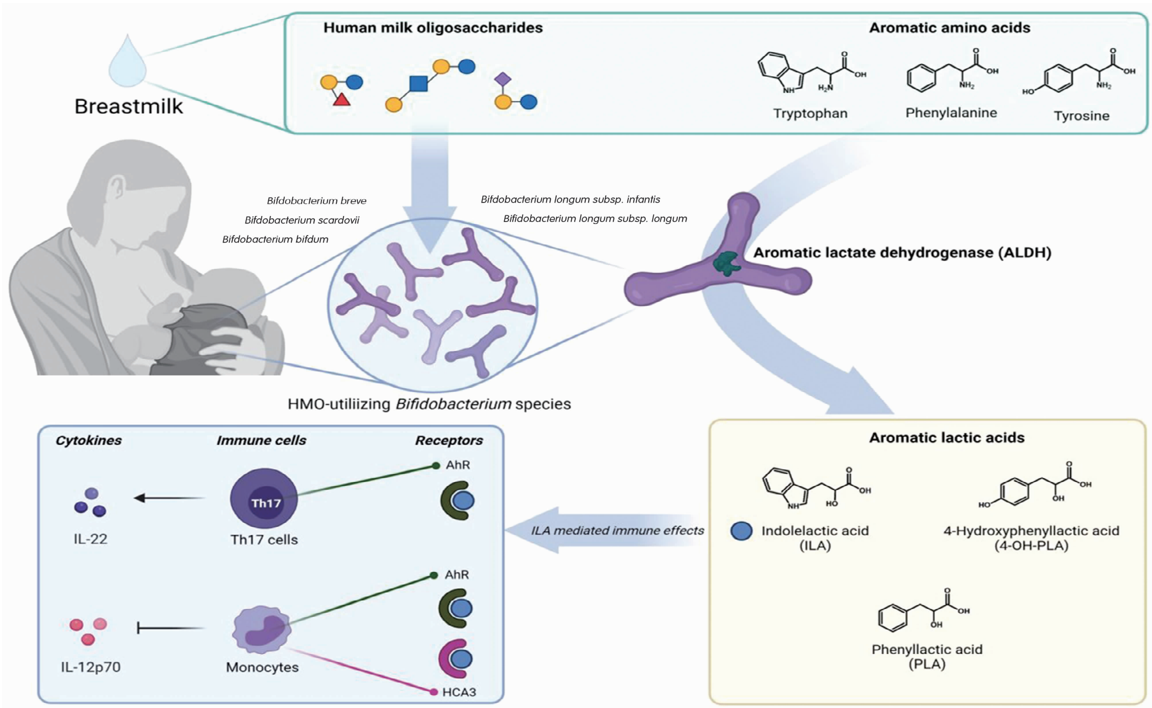

Fig. 2 HMO-utilizing *Bifidobacterium* species, production of aromatic lactic acids and immune-regulation in early life

Conclusions

This paper presented preliminary exploration and summary of instructional design for *Functional Foods* based on the BOPPPS teaching model. Addressing the limitations of traditional teaching methods, we established clear learning objectives and designed student-centered teaching activities in the reform. An assessment and feedback mechanism has been developed by evaluating students' performance in knowledge comprehension, practical application, and innovation ability to monitor learning participation and effectiveness, ultimately stimulating and cultivating students' interest and long-term initiative.

Through implementation of BOPPPS-based teaching reform, students majoring in food can effectively enhance their understanding of the concept of functional foods and their application in food design and processing. In guided learning processes, instructors can promptly assess students' progress and feedback, providing valuable insights for dynamic teaching optimization and personalized instruction. This approach helps strengthen students' practical skills and innovative thinking, meeting the development needs of food science disciplines and talent cultivation. Future research and practice in teaching model reform should further optimize instructional design, evaluation methods, and teacher role transformation to promote the in-depth development and innovation of BOPPPS-based teaching reforms in the education of *Functional Foods*.

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Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU