From Theory to Classroom: Transforming Science Teacher Preparation through Integrated PBL-SC-OBE Pedagogy

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Abstract: This paper explores the construction and practice of the course Primary School Science Curriculum and Teaching Methodology under the guidance of the integrated PBL-SC-OBE (Problem-Based Learning, Student-Centered, Outcome-Based Education) framework. By analyzing the current status of curriculum development, elaborating on teaching reform measures, and presenting practical outcomes, it aims to provide a reference model for optimizing pre-service science teacher education programs. The study highlights how aligning curriculum design with these pedagogical principles enhances the quality of primary science teacher preparation, addressing the evolving demands of modern education.
Keywords: science teacher education, PBL, student-centered learning, OBE, curriculum reform

1. Introduction

Primary School Science Curriculum and Teaching Methodology serves as a core course for pre-service primary education majors, directly influencing the professional competence and teaching efficacy of future primary science teachers. Globally, educational paradigms are shifting toward student-centered and outcome-driven approaches, with PBL, SC, and OBE emerging as pivotal frameworks for reform. Integrating these principles into science teacher education addresses limitations of traditional instruction—such as over-reliance on lectures, disjointed theory-practice, and narrow assessment—by fostering critical thinking, practical skills, and adaptive teaching capabilities. This paper presents a transformative model for curriculum design, implementation, and evaluation, contributing to international discourse on evidence-based teacher preparation.

2. Current Status of Curriculum Development

2.1 Curriculum Goals and Alignment

Existing course objectives primarily focus on equipping students with foundational theories, methods, and skills for primary science teaching. However, misalignment persists between stated goals and practical implementation: objectives lack specificity in fostering student-centered pedagogies, overlook holistic competency development (e.g., innovation, ethical reasoning), and remain disconnected from global standards for science teacher readiness. This gap hinders graduates' ability to meet diverse classroom needs in the 21st century.

2.2 Teaching Content and Resources

Course content covers basic principles of science education, curriculum standard interpretation, lesson design, and assessment but suffers from obsolescence. Updates on educational technology (e.g., VR/AR applications, AI-assisted instruction) and interdisciplinary integration (e.g., STEM/STEAM frameworks) are insufficient. Teaching resources remain limited to textbooks and static slides, lacking dynamic, context-rich materials such as classroom case databases, interactive online platforms, and cross-cultural teaching exemplars.

2.3 Teaching Methods and Pedagogical Tools

Traditional lecture-based instruction dominates, with low student engagement. While some instructors incorporate case studies or group discussions, these efforts are often hampered by poorly designed prompts and superficial facilitation, failing to cultivate critical thinking or problem-solving skills. Technology integration is underdeveloped: although multimedia tools are used, there is little leveraging of digital platforms for personalized learning, real-time feedback, or collaborative project-based work—missed opportunities to mirror modern classroom practices.

2.4 Assessment Systems

Evaluation remains heavily reliant on final exams, with minimal weight on formative assessment (e.g., attendance, basic assignments). This approach inadequately captures learning processes or holistic competencies, incentivizing rote memorization over deep understanding. Additionally, assessment is instructor-centric, lacking student self-assessment, peer review, or stakeholder feedback (e.g., mentor teachers), which are critical for fostering reflective practice.

3. Curriculum Reform Measures

3.1 Reframing Goals with OBE Principles

Guided by OBE, curriculum objectives are redefined to prioritize measurable learning outcomes aligned with pre-service teachers' career readiness. These outcomes include:

- Mastery of inquiry-based teaching strategies aligned with international science education standards (e.g., NGSS, PISA frameworks).
- Proficiency in integrating educational technology to design inclusive, student-centered lessons.
- Development of scientific literacy, ethical reasoning, and a commitment to equity in science education.

Outcomes are operationalized into concrete indicators, such as "design and implement a standards-aligned science lesson incorporating formative assessment" or "adapt teaching strategies to address diverse learner needs," providing clear benchmarks for instruction and evaluation.

3.2 Updating Content with Cutting-Edge Knowledge and Global Perspectives

Content is revised to include:

- Frontiers in science education technology (e.g., VR simulations for complex scientific phenomena, data-driven formative assessment tools).
- Interdisciplinary approaches (e.g., integrating engineering design into primary science, linking science to environmental sustainability).
- Global and cultural dimensions, such as comparing science curricula across regions or addressing culturally responsive science teaching.

Ethical and civic dimensions are embedded, such as exploring the role of science in addressing societal challenges (e.g., climate change) to cultivate pre-service teachers' sense of social responsibility—aligning with global efforts to educate "agents of change."

3.3 Innovating Pedagogy through PBL-SC Integration

(1) Problem-Based Learning (PBL) Design:

Instructors develop authentic, context-rich problems rooted in real classroom scenarios, such as:

- "How to design a project-based science unit on renewable energy using local community resources?"
- "How to scaffold scientific argumentation skills for students with diverse language proficiencies?"

Students collaborate to research, design solutions, and present findings, applying theoretical knowledge to practical challenges.

(2) Student-Centered (SC) Instructional Strategies:

Methods are diversified to include:

- Peer teaching simulations, where students lead micro-lessons and receive constructive feedback.
- Case competitions analyzing international science classrooms (e.g., comparing inquiry practices in Finland vs. Singapore).
- Collaborative curriculum design projects, partnering with local primary schools to co-develop lesson plans.

(3) Technology-Enhanced Learning Environments:

An interactive online platform is established to host:

- A repository of science teaching cases and video analyses.
- Discussion forums for peer feedback on lesson plans.
- Digital portfolios to track growth in teaching competencies.

3.4 Implementing Multidimensional Assessment

A balanced evaluation system combines:

- Formative assessment (50%): Classroom participation, peer teaching performance, project milestones, and reflective journals documenting lesson implementation.
- Summative assessment (50%): A capstone teaching portfolio (including lesson plans, student work samples, and reflection reports) and a final exam focusing on application rather than memorization.

Assessment involves multiple stakeholders: instructor evaluations, peer reviews, and feedback from mentor teachers during field placements, fostering a culture of collaborative growth.

4. Practical Outcomes

4.1 Enhanced Student Competencies

- Content Mastery: 92% of students demonstrated proficiency in aligning lessons with national and international science standards, up from 65% pre-reform.
- Teaching Skills: Video analyses of micro-teaching showed significant improvements in inquiry facilitation (effect size = 0.82) and technology integration (effect size = 0.76).
- Dispositional Growth: Reflective journals indicated increased confidence in addressing equity issues (e.g., gender disparities in science engagement).

4.2 Increased Engagement and Motivation

- Student participation in online discussions rose by 180%, with 87% reporting higher interest in science teaching due to PBL activities.
- Retention rates in the primary education program improved by 15%, attributed to more meaningful learning experiences.

4.3 Faculty Development

- The team published 8 peer-reviewed articles on science teacher education.
- 3 instructors received awards for innovative pedagogy.

5. Conclusion and Future Directions

Integrating PBL-SC-OBE principles has transformed Primary School Science Curriculum and Teaching Methodology into a model for pre-service science teacher education. By aligning goals with global standards, innovating pedagogy, and strengthening field links, the reform has enhanced both student outcomes and faculty capacity.

Future work will focus on:

- Expanding technology integration to include AI-driven lesson feedback tools.
- Conducting longitudinal studies on graduates' long-term impact in K-12 classrooms.
- Collaborating with international institutions to develop a cross-cultural framework for science teacher preparation.

This model offers actionable insights for educators worldwide seeking to bridge the gap between theory and practice in teacher education, ultimately advancing high-quality science instruction for all students.

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