https://ojs.bbwpublisher.com/index.php/ERD Online ISSN: 2652-5372

Print ISSN: 2652-5364

# Study on the Effectiveness of Blended Learning in a Big Data Statistical Analysis Course based on the BOPPPS Teaching Model

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Abstract: This study examines the pedagogical effectiveness of a blended learning approach integrated with the BOPPPS (Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, Summary) instructional model, situated within the context of advancing artificial intelligence and data science education. Using the course 'big data statistical analysis' as a case study, we compare traditional lecture-based instruction with the "BL+BOPPPS" framework to evaluate its impact on online and offline learning outcomes. Our implementation of the "BL+BOPPPS" model demonstrates its effectiveness in fostering student autonomy, enhancing critical thinking skills, and cultivating innovation capabilities. Furthermore, this study contributes to the theoretical foundation for teaching big data statistical analysis, offering evidence-based insights to optimize instructional effectiveness in this discipline.

Keywords: Blended learning; BOPPPS; Teaching effects

Online publication: August 29, 2025

#### 1. Introduction

The rapid proliferation of digital technologies across industries has led to the accumulation of substantial datasets, presenting significant challenges in the analysis of extensive information sources [1-3]. Within the increasingly competitive global digital economy, both commercial entities and governmental organizations have adopted big data analytics as a strategic differentiator. This adoption is driven by multiple convergent factors, including: exponential growth in data volume, continuous technological advancements, heightened market competition, increasing demand for personalized solutions, and growing requirements for risk management. These developments have collectively transformed analytical methodologies in digital management, establishing big data statistical techniques as essential instruments for informed decision-making. The resultant paradigm shift has precipitated the emergence of new academic disciplines, notably Data Science and Big Data Technology,

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Artificial Intelligence Science and Technology, among others.

A large-scale data statistical analysis has become an essential component in multiple disciplines, including Data Science and Big Data Technology, and Artificial Intelligence Science and Technology <sup>[4,5]</sup>. These kinds of courses require students to master core theoretical principles while simultaneously cultivating innovative thinking and robust problem-solving capabilities. These learning objectives are intrinsically aligned with professional competency development, fulfilling key degree program outcomes and graduate attribute requirements in higher education.

Effective learning in big data statistical analysis courses requires undergraduate students to achieve dual competencies: a solid theoretical foundation and practical applied skills, including programming proficiency and analytical reasoning abilities. However, current pedagogical practices that emphasize traditional lecture-based instruction have demonstrated limited efficacy in student engagement and active learning, as substantiated by contemporary educational research <sup>[6,7]</sup>. This pedagogical gap underscores the critical need for developing and implementing innovative instructional strategies augmented by appropriate educational technologies to optimize learning outcomes.

This study proposes a pedagogical reform to address existing deficiencies in big data statistical analysis instruction through the integration of the BOPPPS model with blended learning methodologies. Current instructional practices frequently prove inadequate at addressing undergraduate students' technical skill development and diverse learning needs, leading to reduced engagement and compromised knowledge retention [8,9]. Conventional approaches lack systematic frameworks for establishing clear learning objectives, fostering active participation, and delivering timely feedback with personalized instructional support. The proposed hybrid methodology capitalizes on the synergistic benefits of both pedagogical strategies. The BOPPPS model's structured six-phase framework (Bridge-in, Objective, Pre-assessment, Participatory Learning, Postassessment, and Summary) offers an optimal scaffolding mechanism for organizing complex big data analytics content, while ensuring transparent learning outcomes and systematic knowledge acquisition. This model's emphasis on interactive pedagogy is particularly conducive to developing the practical technical competencies and analytical reasoning skills that are fundamental to the discipline. Concurrently, the blended learning component enables adaptive instruction through real-time performance assessment and individualized learning trajectories. This dual approach effectively accommodates heterogeneous learner populations with varying proficiency levels and learning styles. The integrated methodology is specifically designed to: (1) enhance students' ability to implement statistical models using computational tools, (2) address complex analytical problems, and (3) ultimately achieve superior learning outcomes.

This study aims to rectify and reform current pedagogical shortcomings in big data statistical analysis teaching. It employs a novel combination of the BOPPPS model and blended learning techniques. Conventional approaches to classroom instruction often fail to meet undergraduates' technical skills and diverse educational requirements, resulting in diminished engagement and subpar knowledge retention. A significant deficiency in existing procedures is the lack of systematic mechanisms for establishing objectives, enhancing student engagement, and providing timely feedback with customized instructional support [8,9]. The proposed hybrid approach leverages the complementary strengths of both educational strategies. The BOPPPS model's rigorous six-phase structure (Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, and Summary) provides an ideal scaffold for organizing complex big data analytics content, ensuring transparent learning objectives and methodical knowledge construction. Its focus on interactive pedagogy proves particularly valuable for developing hands-on technical proficiency and analytical reasoning skills essential in this discipline.

Blended learning facilitates adaptive instruction through immediate performance evaluation and customized learning pathways. This accommodates heterogeneous student cohorts with varying skill levels and learning preferences. This synergistic combination is designed to enhance learners' capacity to implement statistical models using computational tools. It is designed to tackle multifaceted analytical challenges and ultimately attain superior educational achievements.

Beyond these core objectives, the investigation will examine the intervention's efficacy in developing applied competencies, fostering cross-disciplinary understanding, and elevating overall course satisfaction metrics among participants. The study thus represents a comprehensive effort to transform big data education through evidence-based pedagogical innovation.

This study comprises three principal components:

- (1) A critical examination of conventional pedagogical approaches to big data statistical analysis instruction, identifying their limitations and establishing the theoretical foundation for combining the BOPPPS framework with blended learning methodologies.
- (2) The systematic development and implementation of an innovative big data statistical analysis curriculum that synergistically incorporates both BOPPPS structural elements and blended learning components, encompassing: (a) precise learning outcome specifications, (b) instructional resource development, (c) interactive session planning, and (d) comprehensive evaluation criteria design.
- (3) An empirical evaluation through controlled experiments and survey research to assess the intervention's impact on key educational metrics. This includes knowledge acquisition levels, applied technical competencies, and overall learner engagement outcomes.

# 2. Theoretical foundation

### 2.1. Concepts and features of blended learning

E-Learning constitutes an umbrella term referring to all forms of electronically mediated learning systems. In contemporary higher education, nearly all instructional processes incorporate various digital resources. The pervasive influence of educational technology has led to its integration even within traditional face-to-face learning environments, with a minimum requirement that lecture materials be made available in digital format. As a result, either all course components or substantial portions thereof are increasingly being delivered through digital format.

Blended learning represents a systematic pedagogical approach that strategically integrates digital and in-person learning modalities. This model involves the deliberate delivery of a portion of course content via online platforms while providing learners with autonomy regarding temporal parameters, progression pace, and educational pathways. Importantly, this approach extends beyond the superficial adoption of digital tools within conventional curricula. Rather, it necessitates a fundamental re-conceptualization of instructional design principles to achieve meaningful synthesis of virtual and physical learning environments. Successful implementation requires: (1) precise alignment with predefined learning objectives, (2) careful consideration of contextual constraints and potential confounding variables, and (3) intentional instructional design to optimize academic interactions among students, instructors, and peer learners [10,11]. This pedagogical model demonstrates particular efficacy in fostering learner engagement while maintaining rigorous academic standards.

Current literature recognizes multiple blended learning frameworks <sup>[12]</sup>, although these typologies largely originate from constrained institutional samples, often confined to the U.S. educational landscape. A pertinent

framework for higher education is the purpose-driven multimodal approach, which asserts that utilizing varied instructional methodologies, delivery methods, and media formats can enhance learning results for diverse student populations <sup>[13]</sup>. This paradigm asserts that certain talents are more efficiently cultivated through inperson engagement, while others yield better results in digital contexts. Empirical data indicate that physical contact most effectively derives interpersonal and emotional support. However, meta-cognitive processes, such as reflective practice, may be improved through asynchronous digital platforms like blogging environments.

An alternative framework emphasizes technological applications for instructional improvement rather than skill development contexts. The reference [14] developed a tripartite classification system based on technological concordances in pedagogical contexts: (1) Transformation Integration - where digital tools shift instructional paradigms from passive knowledge dissemination to active learning engagement; (2) Augmentation Integration - technological implementations that boost either educator efficiency or learner productivity; and (3) Facilitation Integration - technological solutions that improve educational accessibility and logistical convenience. While this taxonomy effectively highlights technology's functional benefits for both instructors and students, it omits critical dimensions including technological implementation specifics, frequency of use, and methodological particulars.

# 2.2. The integration of BOPPPS and blended learning

The BOPPPS instructional framework was initially developed in 1978 by Douglas Kerr, an academic from the University of British Columbia [15]. The BOPPPS, alternatively termed guided interactive additive pedagogy, represents a contemporary educational approach that actively engages educators in curriculum development [16]. Grounded in constructionist and humanistic learning theories, this methodology prioritizes learner-centered teaching practices. Its implementation demonstrates significant potential for enhancing pedagogical outcomes through multiple mechanisms: stimulating learner motivation, optimizing classroom engagement, fostering autonomous learning behaviors, and improving overall teaching efficacy. Characterized by its process-oriented nature, the BOPPPS emphasizes two critical components: active learner participation and systematic feedback mechanisms. These features contribute to its reputation as an exemplary instructional design framework. The approach offers substantial practical advantages, including high operational feasibility and precise instructional targeting. These advantages have established it as a benchmark for faculty development and classroom practice in Canadian tertiary education. Furthermore, its adoption has gained global traction among education professionals, emerging as the predominant pedagogical strategy in European and North American academic institutions [16].

While empirically validated as an effective pedagogical framework, the BOPPPS model has been subject to scholarly critique regarding its rigid six-stage sequential structure [17]. This prescriptive architecture imposes constraints on pedagogical adaptability, particularly in responding to emerging instructional requirements within traditional classroom environments [17]. Educational research has identified the blended learning paradigm as comprising two principal dimensions [18]. The first dimension involves the systematic integration of digital learning resources, as exemplified by micro-lecture media, as foundational components of technology-enhanced blended learning. The second dimension emphasizes constructivist learning principles through structured peer collaboration. Empirical evidence suggests that the strategic incorporation of blended learning methodologies within the BOPPPS framework yields measurable improvements in educational outcomes within tertiary education contexts [19-21]. This intentional design facilitates metacognitive processing and personalized knowledge construction. The model's inherent emphasis on peer-mediated learning and autonomous knowledge integration renders it particularly suitable for implementation within the evaluative and reflective components of the BOPPPS model, promoting deeper conceptual understanding through scaffolding discourse.

# 3. The Application of BL+BOPPPS teaching model in the Big Data Statistical Analysis course

This study implemented a comparative methodology employing digital pedagogical resources hosted on China's national MOOC platform (accessible via https://www.icourse163.org). The instructional design incorporated structured formative evaluation mechanisms, with each curricular unit containing: (1) Pre-instructional knowledge checks (2–5 questions per module), (2) Summative module assessments (8–12 questions per unit). The team developed a bespoke Small Private Online Course (SPOC) environment within the existing MOOC infrastructure, establishing a dedicated digital learning ecosystem. This integrated platform supported three critical educational functions: (1) Time-shifted content dissemination, (2) Algorithmic evaluation protocols, and (3) Comprehensive learner analytics capture. For synchronous instructional delivery, investigators utilized MOOC Classroom - a responsive mobile application built upon institutional MOOC architecture. This technology solution facilitated: didactic interchange, feedback mechanisms, and collaborative learning spaces. The implemented pedagogical framework strategically merged traditional classroom instruction with technology-enhanced learning modalities, yielding an integrated educational paradigm that optimized both synchronous and asynchronous learning opportunities.

# 3.1. Pre-class preparation

The class online Dingtalk group was set up, and students were given a preview of the content through the learning content of this course on the MOOC platform of Chinese universities in advance. The instructional design incorporated a structured pre-class preparation phase utilizing multiple digital platforms: (1) Digital Learning Environment Establishment: a dedicated course communication channel was created using DingTalk's enterprise features; pre-instructional materials were deployed through China's national MOOC infrastructure. (2) Pre-Class Resource Composition: concept introduction videos (average duration: 8–12 minutes); annotated slide presentations (Microsoft PowerPoint format); guided reflection prompts (3–5 critical thinking questions per module). This resource integration strategy served dual purposes: facilitated seamless incorporation of digital assets into the BOPPPS framework and provided diagnostic data for the initial assessment phase. Students completed these preparatory activities following prescribed protocols: mandatory engagement with all pre-class materials; submission of structured responses to reflection questions; generation of digital learning traces (time logs, interaction patterns).

#### 3.2. In-class teaching

The face-to-face instructional sessions were structured according to the BOPPPS pedagogical framework. During the initial engagement phase, instructors presented contemporary case studies directly aligned with course objectives to stimulate learner curiosity and establish relevance. Instructional content was dynamically adapted based on real-time formative assessment data collected through digital feedback mechanisms and continuous performance monitoring. The participatory learning component employed a technology-enhanced constructivist approach, wherein (1) MOOC resources facilitated scaffolded discussions, (2) critical thinking exercises promoted cognitive development, and (3) collaborative problem-solving cultivated both disciplinary competencies and transferable skills, and a multimodal feedback system was implemented. This integrated methodology enabled the immediate identification and resolution of learning obstacles through peer-mediated

and instructor-facilitated discourse.

#### 3.3. Post-class reinforcement

To comprehensively assess learning outcomes and reinforce knowledge retention, summative evaluations and supplemental assignments were administered through digital assessment platforms. This approach serves dual purposes: (1) verifying attainment of predefined learning objectives, and (2) facilitating knowledge consolidation through repeated practice in a structured manner. To overcome the temporal constraints inherent in traditional classroom settings, the instructional team implemented an extended learning framework via the DingTalk collaborative platform. The digital environment enabled: (1) asynchronous scholarly discourse, (2) extended case study analysis, and (3) interdisciplinary knowledge integration. The implemented extension activities were specifically designed to enhance three core competencies: knowledge application, skills development, and creative problem-solving capacity. This blended assessment strategy effectively bridges formal instruction with continuous learning opportunities, fostering deeper engagement and intellectual growth beyond physical classroom boundaries.

#### 4. Evaluation and assessment mechanisms

This study involved 138 third-year undergraduate students enrolled in the Data Science and Big Data Technology program across two academic years. All participants expressed career aspirations in data-related fields, encompassing postgraduate studies, corporate employment, and public sector positions. According to most students, the new teaching mode promotes their initiative, understanding, and reflection on the course. The BL+BOPPPS teaching model, in contrast to the standard teaching model, offers more teaching sessions and materials, as well as more online and offline learning and discussion tasks. Students perceived this to increase their learning workload and pressure. There were also more sessions and tasks to complete, which contributed to the increased workload. Students in conventional lecture-based teaching methods learn by rote and are not capable of thinking independently and making independent decisions. In contrast, the BL+BOPPPS model fully mobilizes and improves students' learning initiative and comprehensive skills. Increasing regular coursework scores in different teaching sessions helped students participate actively in the lessons and complete the learning tasks by 'inducing' them to do so. As a result, a comprehensive, scientific, efficient, and feasible process-oriented evaluation system could be developed that was more conducive to teaching effects and purposes. There were also some problems exploiting the BL+BOPPPS teaching model. For instance, teachers need excellent teaching skills and an in-depth grasp of professional knowledge. They need to gather and process information, develop and design resource combinations and organize the whole class when using MOOC to introduce and preview knowledge. Information and skills take time to develop.

In addition, pupils were forced to have high self-discipline because of DingTalk on their cell phones for studying. Ultimately, it was determined that such a condition was more effective for small classes in facilitating summarization and in-depth learning; furthermore, to mitigate the tendency of certain students to depend on the group leader and disengage from the learning process, it was essential to assign roles and tasks to each student within the group and ensure that all participants had the opportunity to articulate their viewpoints during discussions and presentations.

#### 5. Conclusion

This study examined the pedagogical efficacy of incorporating the BOPPPS framework within a blended learning environment. It focused on learner perceptions and academic outcomes. The implemented instructional design systematically decomposed each instructional module into six distinct components (introductory bridge, learning objectives, diagnostic assessment, engaged participation, summative evaluation, and synthesis) across three temporal domains (pre-class, in-class, and post-class activities). The synthesized BL+BOPPPS pedagogical approach demonstrated significant structural advantages over conventional lecture-based instruction, particularly in the context of delivering Big Data Statistical Analysis coursework. Empirical data collected from undergraduate participants revealed several noteworthy findings. The robustness of these findings suggests that the BL+BOPPPS paradigm warrants serious consideration for broader implementation within China's higher education landscape. Its demonstrated capacity to improve both cognitive and affective learning dimensions while maintaining structural clarity presents a compelling case for curricular innovation.

# **Funding**

First-class Undergraduate Course Construction Project of Zhejiang University of Science and Technology (Project No.: 2023-k13)

#### Disclosure statement

The authors declare no conflict of interest.

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