Towards a Pedagogically Aligned Blended Learning Framework for Foundation Computing Education: Evidence from Behavioural Learning Analytics of Engineering Undergraduates

I. P. Ratnapala

Computing Centre, Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka
iroshinir@eng.pdn.ac.lk

Undergraduate engineering students possess diverse skills, necessitating a well-structured foundation for a smooth transition to tech-enhanced learning. However, many blended teaching methods are ad hoc and misaligned with learner readiness, topic difficulty, or learning outcomes. This study proposes a Pedagogically Aligned Blended Course Design Framework for Foundation Computing in engineering programmes. Unlike existing blended learning models that primarily prescribe instructional methods or technology integration, this framework provides a systematic process for aligning learner readiness, topic complexity, cohort feedback, and ILOs with appropriate blended strategies. This alignment enables lecturers to make evidence-informed instructional decisions rather than adopting blended learning practices in an ad hoc manner. By integrating these pedagogical dimensions into a repeatable course design process, the framework provides a practical approach for developing adaptive, scaffolded, and learner-centred Foundation Computing courses in engineering education. The curriculum was organised into six instructional clusters: face-to-face instruction, external online courses, instructional videos, interactive videos, interactive lessons, and annotated learning materials. Formative assessments integrated game-based learning, peer review, and automated programming practices within the Moodle LMS. The framework was implemented in a six-week programme at the Faculty of Engineering, University of Peradeniya, in 2025. After preprocessing and removing missing data and outliers, data from 282 students were analysed using R. The evaluation encompassed pre- and post-assessment analysis, LMS behavioural analytics, and qualitative feedback analysis. Descriptive statistics indicated that pre-assessment scores had a mean of 46% (SD=9.38), whereas post-assessment scores had a mean of 83% (SD=15.29). A paired-samples t-test demonstrated a statistically significant improvement in post-assessment scores ($t(280) = 41.07$, $p < 0.001$), with a mean learning gain of 37.08 points and a very large effect size ($d = 2.45$). Furthermore, a Wilcoxon Signed-Rank test confirmed the significance of the improvement ($p<0.001$). Correlation analysis revealed weak relationships between basic LMS usage indicators (such as login frequency and time spent) and performance outcomes; however, LMS activity completion, configured across all course activities, exhibited a strong positive correlation with learning gain ($r=0.681$, $p<0.001$). Qualitative feedback further underscored students' positive perceptions of interactive activities, personalised guidance, clear navigation, and game-based learning. The findings suggest that effective blended learning environments in engineering education should be developed through pedagogically aligned instructional planning rather than technology-driven implementation. The proposed framework demonstrates how learner readiness, curriculum complexity, and ILOs can be systematically mapped to blended teaching strategies to establish adaptive, evidence-based, and engagement-oriented Foundation Computing courses.

Keywords: blended learning, engineering education, learning analytics, instructional design, Moodle