IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Theoretical Framework for Activity-Based Learning: Integrating 21st-Century Language Competence and Digital Employability in Engineering Education

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Abstract: In Industry 4.0, engineering students are required to have strong communicative, collaborative and digital skills in addition to technical competency. Yet, language education in engineering is often isolated and not integrated with employability requirements. This paper seeks to bridge this gap by proposing a framework that combines Activity-Based Learning (ABL) with 21st-century language development and digital employability skills. Drawing on Constructivism and Experiential Learning Theory and informed by the 21st Century Skills Framework, this research synthesizes the literature to develop theoretical connections between language teaching and learning outcomes. The framework defines ABL as a practical and experiential learning process that involves cognitive processing, social interaction and reflective inquiry, all of which contribute to improved communication skills and digital employability among engineering students. The paper proposes six theoretical claims on how ABL impacts language skills and digital employability potential. This research provides an integrated model for engineering education, addressing the gap in unified approaches that link language learning to digital employability.

Index Terms **-** Activity-Based Learning (ABL), 21st-Century Skills, Engineering Education, Language Competence, Digital Employability, Conceptual Framework, Experiential Learning, Constructivism

I. Introduction

The emergence of Industry 4.0 has reshaped the skill sets required of engineering graduates, extending beyond technical knowledge to include higher-order communication, collaboration and digital skills. There is a growing demand for professionals with strong communication, teamwork and digital literacy. However, engineering curricula remain skewed towards technical proficiency, while neglecting the holistic development of language and employability skills critical for workplace success.

Language learning in engineering is often delivered through conventional classroom methods that are disconnected from workplace contexts. At the same time, digital employability skills (including the use of collaborative tools, digital content creation and technological adaptation) are either presumed or under-evaluated in the curriculum. This disconnect between language teaching practices and workplace demands presents a clear challenge for curriculum developers and policymakers.

The impact of this misalignment is well documented in research on graduate employability. International and interdisciplinary workplaces, in which English is used as a lingua franca and digital platforms are used to coordinate teamwork, place engineering graduates with insufficient communicative competence at a disadvantage [12], [13]. Similarly, graduates who lack experience with authentic digitally mediated tasks during their university education are often ill-equipped to keep up with the pace of technological change in modern workplaces [18], [19]. Both of these gaps, in communicative competence and digital employability, are systemic, resulting from the treatment of language and technology as add-ons rather than core learning outcomes in the curriculum.

Activity-Based Learning (ABL) is one such approach. Drawing on Constructivist and Experiential Learning Theories, ABL engages learners in authentic, task-oriented activities, with learning driven by interaction and reflection [1], [2]. Existing studies have shown ABL's effectiveness in improving engagement, critical thinking and skill development in engineering education [6], [7]. However, these studies primarily focus on ABL in isolation or within narrow disciplinary contexts and have not fully explored its potential to simultaneously support language proficiency and digital employability. The integration of these two dimensions within a unified, theoretically grounded ABL approach remains largely unexplored.

This requires more than marginal adjustments to existing pedagogical approaches. It calls for a cohesive theoretical framework that explains how ABL activities influence language and employability outcomes, one that is rooted in established learning theory, responsive to 21st-century skills demands and directly applicable to engineering curriculum design. Without such a framework, efforts to enhance language pedagogy and digital skills in engineering education will remain fragmented, limiting the potential of integrated approaches.

In response to this challenge, this paper proposes the ABL-DE conceptual framework, which integrates Activity-Based Learning with 21st-century language competence and digital employability outcomes. By synthesizing established theories and identifying key constructs and relationships, this study provides a cohesive model that bridges fragmented research areas and offers a foundation for future empirical testing and curriculum development.

II. Literature Review

A. **Theoretical Foundations: Constructivism and Experiential Learning**

ABL pedagogy builds on the foundations of constructivism and experiential learning. Constructivism, as articulated by Vygotsky [1], understands knowledge as socially constructed through interaction in a culturally situated context. A key element of this theory is the Zone of Proximal Development (ZPD), which is defined as the distance between the actual developmental level as determined by independent problem solving and the level of potential development achieved through guidance from a more capable peer [1, p. 86]. The ZPD underpins peer scaffolding, dialogic instruction and collaborative tasks used in ABL classrooms.

Building on this idea, Kolb [2] developed Experiential Learning Theory (ELT), which views learning as a continuous four-stage process of concrete experience, reflective observation, abstract conceptualization and active experimentation. Kolb described learning as "the process whereby knowledge is created through the transformation of experience" [2, p. 38]. Mughal and Zafar [3] adapted this model to incorporate collaborative and technologically mediated aspects, making it more applicable to 21st-century higher education. Moreover, Wijnen-Meijer et al. [4] found that explicitly linking didactic methods within the Kolbian cycle led to improved learning outcomes in professional education, a principle applicable to ABL design in engineering education.

B. Activity-Based Learning in Engineering Education

ABL has been identified as a potential solution to the disconnect between traditional lecture-based teaching and the applied, collaborative skills required in modern engineering workplaces. Gopalan et al. [5] noted that sustained motivation, a prerequisite for deep learning, is best fostered through active engagement with content, drawing on self-determination theory, social cognitive theory and the ARCS model. Active learning has been adopted in various formats in engineering education, including problem-based learning (PBL), project-based learning (PjBL), cooperative learning and team-based learning (TBL) [6]. Ariza [6] observed that the integration of practical activities, mobile technologies and group work led to improvements in both technical and communication skills.

A recent systematic review by Pacher et al. [7] on competence-based education in industrial engineering found that communication, digital and collaborative work skills are increasingly emphasized by employers but are not consistently integrated into engineering education. The study recommended integrated models that embed language and soft skills development within disciplinary learning.

C. 21st-Century Skills Frameworks and Language Competence

The Partnership for 21st Century Learning (P21) [8] proposed an integrated framework based on four interrelated skill sets: critical thinking, communication, collaboration and creativity (the "4Cs"). Importantly, P21 argues that communicative competence is not a standalone linguistic skill but a foundational element enabling other 21st-century skills. Dede [9] conducted a comparative analysis of frameworks such as P21, OECD key competencies and ISTE standards, identifying three common dimensions: the interactive use of tools, including language and digital technologies, interaction in heterogeneous groups and autonomous action.

Canale and Swain [10] laid the groundwork for the model of communicative competence, originally identifying three interrelated sub-competencies: grammatical, sociolinguistic and strategic competence. Canale [11] later expanded this model by including discourse competence as a fourth component, forming the widely cited four-component framework. The relevance of this model to ABL in engineering education lies in its emphasis on authentic communicative performance, which naturally occurs in group activities, design presentations and collaborative reports, as the most effective way to develop these interconnected competencies.

D. English Language Learning in Engineering Education

While language skills are critical for professional engineering practice, language development in engineering education has traditionally been relegated to standalone courses that are often not explicitly connected to disciplinary knowledge. Roshid and Kankaanranta [13] found that employers in the global ready-made garment industry in Bangladesh value practical, relevant and professional communicative skills, as well as trade-specific language, over purely grammatical ability, suggesting the need for pedagogies that embed language learning in communicative activities.

Han [14] systematically reviewed the impact of problem-based learning (PBL) on English Language Teaching (ELT) in Korean universities and found that PBL was consistently associated with improvements in both language learning and problem-solving skills. Costa and Mastellotto [15] showed that discipline-specific language training led to improvements not only in comprehension but also in productive language skills, highlighting the need to align language teaching with discipline-specific communication demands.

E. Digital Competencies, Job Readiness and Industry 4.0

Industry 4.0 has changed the competency requirements for engineering graduates. Pacher et al. [7] traced the increasing focus on digital skills in engineering education, concluding that integrated approaches to competence development are required across disciplines. Dorđević et al. [16] demonstrated, through cross-sectional data analysis, that digital skills are a gateway to employability, with information literacy and digital communication identified as the most important employability-related components. Geng et al. [17] reviewed studies on employability skills in the construction industry, a field closely related to engineering, and found that adaptability, communication and digital skills represent emerging areas of focus across technical domains.

De Villiers Scheepers et al. [18] demonstrated that digital competence for employability extends beyond social media proficiency and includes the flexible use of digital tools, data literacy, online collaboration and working with digitally mediated relationships. Tee et al. [19] reported that Malaysian graduates consistently underperformed across five domains of digital competence, identifying information literacy, collaborative digital tools and problem-solving through technology as the most critical yet underdeveloped competencies, with direct implications for engineering education.

F. Technology-Enhanced and Collaborative Language Learning

Fikria et al. [20] reviewed technology-enhanced project-based language learning and found that digital tools supported improved understanding of discipline-specific genres, collaborative writing and sustained engagement with disciplinary discourse. The benefits of collaboration in developing communicative competence are well established. Bozkurt and Aydin [21] used an experimental design to show that collaborative tasks significantly reduced foreign language speaking anxiety in both face-to-face and online settings, supporting the case for collaborative ABL approaches in language-integrated engineering instruction. Ng, Chan and Lit [22] found that structured digital collaboration produced gains in communicative outcomes comparable to face-to-face interaction, while also improving students' asynchronous digital communication skills, which are essential in hybrid work environments.

G. Gaps in the Literature

The above review shows a broader pattern. While the individual domains of ABL, 21st-century language competence and digital employability have been extensively studied, their interrelationships within engineering education remain underexplored. Existing frameworks typically emphasize either pedagogical processes or outcomes, without clearly explaining how specific practices lead to specific competency development. Moreover, most studies have either been conducted in non-engineering contexts [14], [20] or have examined language and digital competencies separately [16], [18]. The framework proposed in this study addresses this limitation by grounding these relationships in established theoretical perspectives and presenting propositions that can be empirically tested.

III. Methodology

This study adopts a qualitative, theory-building approach grounded in systematic conceptual synthesis to develop a unified framework linking ABL with 21st-century language competence and digital employability in engineering education. A structured multi-stage literature screening process was applied to identify relevant studies from major academic databases including Google Scholar, Scopus, IEEE Xplore and SpringerLink, focusing on peer-reviewed publications between 2010 and 2025.

Searches were conducted using keywords such as “Activity-Based Learning,” “engineering education,” “language competence,” “digital literacy” and “employability skills.” Results were filtered through title and abstract screening, followed by full-text review to ensure theoretical relevance and alignment with the study’s objectives. A semi-automated filtering approach was used to assist in identifying and organizing relevant literature, followed by manual validation to confirm the appropriateness of each source for inclusion.

Inclusion criteria comprised studies that: (i) examined ABL or related pedagogical approaches in higher education; (ii) addressed language learning in professional or engineering contexts; and (iii) explored digital skills or employability outcomes. Studies lacking theoretical grounding or not aligned with higher education contexts were excluded, as were those that were not peer-reviewed or that focused solely on primary or secondary education. Table I provides an illustrative overview of the screening stages applied.

TABLE I
Illustrative Screening Process

Stage	Outcome
Initial database search	Broad pool of records identified
Title/abstract screening	Narrowed to thematically relevant studies
Full-text review	Applied inclusion/exclusion criteria
Final synthesis	Theoretically grounded studies retained

The study used thematic coding and synthesis. The first pass inductively identified constructs from the literature, such as engagement, collaboration, reflection and digital interaction. In a second pass, these constructs were aligned with existing theories, ensuring congruence with Constructivism and Experiential Learning Theory. During a third pass, the constructs were consolidated through clustering to explore interrelationships and recurring themes; constructs mentioned in fewer than three independent sources were removed from the core model to ensure theoretical saturation. The ABL-DE (Activity-Based Learning for Digital Employability) model was then developed based on this synthesis and consists of four interrelated layers, along with a set of theoretical propositions that provide a structured foundation for future empirical validation.

IV. Type Conceptual Framework Development And Discussion

The primary outcome of this study is the ABL-DE conceptual framework, which integrates Activity-Based Learning with 21st-century language competence and digital employability outcomes in engineering education. As illustrated in Figure 1, the model conceptualizes four connected layers: ABL activity inputs, learning processes, mediating variables and co-developed outcomes. A feedback arrow from the outcome layer back to the process layer reflects the synergistic integration effect theorized in P6, whereby the joint development of language and digital competencies reinforces and deepens subsequent engagement with ABL activities.

At the process level, four key mediated mechanisms are identified: engagement, collaboration, reflection and digital interaction. These mechanisms translate ABL inputs into outcomes. A key theoretical contribution is the identification of two mediating variables, cognitive engagement and communicative scaffolding, which explain how ABL processes influence outcomes. Cognitive engagement reflects the depth of mental processing applied to learning tasks, while communicative scaffolding describes the structured peer and instructor support through which learners internalize communicative norms within the ZPD [1]. This distinction clarifies the conceptual difference between Layer 2 processes, which represent collaborative activity as a pedagogical design feature, and Layer 3 mediators, which capture the internal cognitive and social mechanisms activated by that design.

A. Theoretical Propositions

Based on the foregoing synthesis, the following propositions formalize the relationships embedded in the ABL-DE framework:

P1: ABL activities (collaborative projects, presentations and simulations) positively influence students' cognitive engagement in engineering learning environments.

P2: Cognitive engagement, as stimulated by ABL activities, mediates the relationship between pedagogical inputs and language competence outcomes.

P3: Social interaction within ABL contexts positively influences the development of communicative competence, including grammatical, sociolinguistic, strategic and discourse sub-competencies [10], [11].

P4: Digital interaction embedded in ABL activities positively influences students' digital employability readiness in Industry 4.0 contexts.

P5: Reflective learning, as a process component of ABL, strengthens the transferability of both language and digital competencies from educational to professional settings.

P6: As a novel proposition of this framework, the joint development of language competence and digital employability through ABL is theorized to be stronger than the development of either competency in isolation, reflecting a synergistic integration effect that warrants empirical investigation.

The framework explicitly integrates language competence and digital employability as co-developed outcomes rather than independent constructs. Table II illustrates how specific ABL activities translate into measurable skill development, directly addressing the major limitation in existing literature where these domains are treated in isolation.

TABLE II

Mapping ABL Activities to Language and Employability Skills

ABL Activity	Language Skill	Employability Skill
Technical Presentations	Verbal Communication	Professional Communication
Group Projects	Collaborative Communication	Teamwork
Digital Content Creation	Writing Skills	Digital Literacy
Simulations / Role Play	Contextual Language Use	Decision-Making

In comparison to existing models that focus primarily on either engagement, technical skill development or general employability, the ABL-DE framework provides a holistic and theoretically grounded structure tailored to engineering education.

V. Conclusion

This research produced the ABL-DE theoretical model that brings together Activity-Based Learning (ABL), 21st-century language competence and digital employability in engineering education. Drawing on established theories from Constructivism, Experiential Learning Theory and 21st-century skills, the model offers a structured account of how active, collaborative and experiential pedagogies lead to language and digital employability outcomes for engineering students.

The main contribution of this study is the integration of three previously disjointed research areas, pedagogy, language learning and digital employability, into a single, theoretically grounded framework. The ABL-DE model extends descriptive accounts of active learning by specifying the mediating roles of cognitive engagement and communicative scaffolding, and by proposing six propositions that explicitly link ABL inputs to language and employability outcomes. In doing so, it addresses a gap in engineering education literature by positioning language development and digital employability not as ancillary outcomes, but as co-developed and mutually reinforcing results of effective pedagogical design.

In practical terms, the model serves as a guide for curriculum designers and engineering educators to embed language-oriented and digitally mediated tasks within disciplinary learning, rather than treating them as standalone courses. The propositions generated from this synthesis are intended to be empirically testable and provide a starting point for the development of instruments, interventions and program evaluation strategies in future research.

VI. Future Scope

The model presented provides a solid foundation, but there are several important directions for future research. First, the ABL-DE model should be tested empirically across different engineering education settings. Structural equation modeling and other quantitative methods can be used to validate the relationships between ABL inputs, cognitive engagement, communicative scaffolding and outcomes such as language proficiency and digital skills. Additionally, mixed-methods research can provide deeper insights into students' experiences, enhancing the model's explanatory power.

Future work should also investigate the role of emerging technologies in ABL environments, such as AI-based tools, adaptive systems and human-AI interactions, to understand their impact on the learning process and whether refinements to the model are required. Longitudinal research is also important to assess the retention and transferability of skills developed through ABL over time. Extending the model to broader STEM, business and vocational contexts would further help evaluate its generalizability and applicability.

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