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Assessment-Task Calibration against Competence Progression in Project-Based Management Courses

Zewdu Wolde, Marta Desta

Department of Plant Biology and Biodiversity Management, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia

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Abstract:

The alignment of assessment tasks with the progressive development of student competences remains a critical challenge in higher education, particularly within project-based management courses. These courses inherently demand the synthesis of theoretical knowledge and practical application, necessitating assessment mechanisms that evolve in complexity alongside the learners cognitive and operational progression. This paper investigates the concept of assessment-task calibration, an instructional design strategy that dynamically aligns formative and summative evaluations with predefined milestones of competence acquisition. Through a comprehensive longitudinal analysis, this study evaluates how calibrated assessment architectures influence student learning outcomes, skill retention, and intrinsic motivation compared to traditional, static assessment models. The research employs a mixed-methods methodology, integrating quantitative performance metrics from student cohorts with qualitative feedback from educators and industry stakeholders. Findings indicate that dynamically calibrated tasks significantly enhance students abilities to master complex project management domains, such as risk mitigation, stakeholder communication, and resource allocation. Furthermore, the systematic alignment reduces cognitive overload during the initial phases of learning while providing adequate rigor during advanced stages. This paper provides a robust theoretical framework and practical guidelines for educators to implement assessment calibration, ultimately fostering more effective and equitable project-based management education.

1.INTRODUCTION

1.1 Context and Motivation

In the contemporary landscape of higher education, the paradigm of teaching and learning has shifted significantly from passive knowledge transmission to active, experiential models. Among these models, project-based learning has emerged as a cornerstone methodology, particularly within management education. Project-based management courses are uniquely positioned to bridge the gap between academic theory and professional practice, as they require students to engage with authentic, ill-structured problems that mirror the complexities of the modern business environment. In such courses, students are not merely expected to memorize project management frameworks; they must apply them dynamically to initiate, plan, execute, monitor, and close projects. The underlying pedagogical assumption is that engaging with these practical scenarios fosters a continuous progression of competences, ranging from fundamental cognitive understanding to advanced behavioral and interpersonal skills. The importance of this pedagogical approach is underscored by the increasing demands of the global workforce, where employers consistently prioritize graduates who possess demonstrable problem-solving capabilities, adaptability, and collaborative acumen. However, realizing the full potential of project-based learning depends entirely on the efficacy of the assessment mechanisms utilized to evaluate student progress. Assessments in this context serve a dual purpose: they are instruments for measuring learning outcomes and critical drivers of the learning process itself [1]. When assessment tasks are thoughtfully designed and strategically deployed, they provide vital scaffolding that guides students through the successive stages of competence acquisition.

1.2 Problem Statement

Despite the widespread adoption of project-based management courses, a pervasive misalignment exists between the assessment tasks administered and the actual trajectory of competence progression expected of students. Traditional assessment paradigms often rely on static evaluation methods, such as standardized mid-term examinations or monolithic final project reports, which fail to capture the nuanced, iterative development of skills over time. Consequently, students may face tasks that are either excessively complex early in the course, leading to cognitive overload and demotivation, or insufficiently challenging during the final stages, failing to stimulate higher-order critical thinking. This lack of calibration compromises the validity of the assessments, as the grades awarded may not accurately reflect the students true managerial competences [2]. Furthermore, uncalibrated assessments often focus disproportionately on explicit knowledge retention rather than the tacit, practical skills required in real-world project management, such as conflict resolution, agile adaptation, and stakeholder negotiation. The discrepancy between what is taught, what is practiced, and what is assessed creates a fragmented learning experience [3, 4]. Without a systematic method to calibrate assessment tasks against defined milestones of competence progression, educators struggle to provide timely, actionable feedback, and students are left without clear indicators of their professional development. This fundamental gap in instructional design limits the transformative potential of project-based management education.

1.3 Research Objectives and Scope

The primary objective of this paper is to explore, define, and evaluate the concept of assessment-task calibration as a mechanism for enhancing competence progression in project-based management courses. To achieve this, the research pursues three specific aims. The first aim is to synthesize existing literature on project-based learning, competence modeling, and assessment theory to construct a comprehensive conceptual framework for calibration. The second aim is to empirically investigate the impact of implementing calibrated assessment tasks on student performance, utilizing a multi-year longitudinal study design across multiple management course cohorts. The third aim is to identify the practical challenges and pedagogical implications of

adopting this calibrated approach for educators and institutional policy. By addressing these objectives, this paper seeks to provide empirical evidence and actionable guidelines that will enable instructional designers and faculty members to create more responsive, equitable, and effective learning environments [5]. The scope of this study is focused specifically on undergraduate and graduate-level project management curricula, though the principles of assessment calibration discussed herein are intended to be generalizable to other disciplines that rely heavily on experiential and problem-based learning modalities.

2. Theoretical Background and Literature Review

2.1 Evolution of Project-Based Management Courses

The historical trajectory of management education reveals a gradual but decisive movement away from purely didactic lectures toward immersive, active learning environments. In the early stages of management pedagogy, the curriculum was heavily reliant on case study methodologies, which, while valuable for analytical training, often positioned the student as an external observer rather than an active participant. The introduction of project-based learning into management curricula represented a paradigm shift, anchoring student learning in the active construction of knowledge through tangible project deliverables. This pedagogical evolution was deeply influenced by constructivist learning theories, which posit that learners build their own understanding and knowledge of the world through experiencing things and reflecting on those experiences [6]. In the context of project management, this means that students learn how to manage scope, schedule, and resources not just by reading about these concepts, but by actively negotiating them within a simulated or real-world project team. Over the past two decades, professional organizations shaping project management standards have also revised their competency frameworks to emphasize not only technical skills but also behavioral and contextual competencies [7]. Consequently, modern project-based management courses are expected to cultivate a holistic skill set. The literature extensively documents the benefits of this approach, noting significant improvements in student engagement, long-term knowledge retention, and readiness for professional certification [8]. However, the literature also consistently highlights that the transition to project-based learning is frequently hindered by legacy assessment structures that were designed for traditional didactic teaching.

2.2 Competence Progression Models in Higher Education

Competence, within the academic discourse, is generally understood as a complex integration of knowledge, skills, attitudes, and behaviors that enable an individual to perform a specific role effectively. In higher education, mapping how these competences develop over time is critical for designing effective curricula. Various theoretical models have been proposed to conceptualize this progression. One of the foundational frameworks is the developmental model of skill acquisition, which posits that learners pass through distinct stages: novice, advanced beginner, competent, proficient, and expert. In a project-based management course, a student might begin as a novice who strictly follows given rules for drafting a project charter, without understanding the broader context. As they progress to an advanced beginner, they start recognizing situational elements, such as the impact of resource constraints on a timeline. By the time they reach the competent stage, they can formulate plans, manage multiple variables simultaneously, and take responsibility for project outcomes [9]. Another critical framework is the taxonomy of educational objectives, which categorizes cognitive tasks from lower-order processes like remembering and understanding, to higher-order processes like analyzing, evaluating, and creating. Integrating these developmental models into a unified theory of competence progression for project management requires identifying specific, observable milestones. For instance, competence in risk management progresses from the ability to identify potential risks (cognitive comprehension) to the ability to design and implement complex mitigation strategies during a project crisis (behavioral

application). The literature emphasizes that unless these developmental milestones are explicitly defined, it is impossible to accurately align instructional activities or assessments with the learners current stage of development [10, 11].

2.3 The Gap in Assessment Calibration

Despite the robust theoretical understanding of competence progression, a substantial gap remains in how assessments are designed to measure this progression dynamically. The concept of calibration in educational assessment typically refers to the process of adjusting the difficulty and discrimination of test items. However, in the context of authentic, project-based tasks, calibration must be understood more broadly as the continuous, intentional alignment of the tasks complexity, scope, and evaluation criteria with the targeted stage of student competence [12]. Currently, much of the literature points to a phenomenon of static assessment rubrics that apply expert-level expectations to novice-level tasks, or conversely, fail to demand expert-level synthesis at the conclusion of a course [13]. This misalignment creates several pedagogical issues. When tasks are calibrated too high initially, students experience frustration, leading to a superficial adoption of project management tools rather than a deep, internalized understanding of their utility. When tasks are not progressively calibrated upward, students do not experience the cognitive dissonance necessary to drive the development of higher-order management skills, such as strategic alignment and crisis leadership. Furthermore, the lack of assessment calibration often results in a failure to adequately measure soft skills, as early assessments focus heavily on technical outputs (e.g., Gantt charts) while neglecting the assessment of evolving team dynamics. Research indicates that dynamic assessment calibration requires a systemic approach where formative feedback loops are tightly integrated with subsequent task design, allowing the assessment mechanism to adapt to the learners demonstrated progression [14].

3. Conceptual Framework for Assessment Calibration

3.1 Defining Assessment-Task Calibration

Assessment-task calibration, as conceptualized in this research, is defined as the deliberate and systematic instructional design process of aligning the cognitive, psychomotor, and affective demands of an assessment task with the expected developmental milestone of the learner. This process requires a departure from viewing assessments merely as endpoints of learning; instead, they must be viewed as structural components of the learning architecture. Calibration involves three interconnected dimensions: task complexity, scaffolding intensity, and evaluation criteria strictness. Task complexity refers to the number of variables, the level of ambiguity, and the required depth of analysis embedded in the assignment. Scaffolding intensity relates to the amount of instructional support, templates, and guidance provided to the student to complete the task. Evaluation criteria strictness pertains to the rubrics used to grade the task, specifically whether they reward basic compliance or demand sophisticated synthesis and innovation. In a perfectly calibrated environment, task complexity increases sequentially, scaffolding intensity decreases proportionately, and evaluation criteria shift from rewarding fundamental comprehension to demanding autonomous, professional-level execution. This dynamic adjustment ensures that the student is consistently operating within their zone of proximal development, where the challenge is sufficient to stimulate growth without causing insurmountable frustration. Implementing this definition requires educators to meticulously deconstruct their project-based management courses into specific competence milestones and intentionally engineer tasks that act as bridges between these milestones.

3.2 Dimensions of Competence Progression

To effectively calibrate assessment tasks, it is necessary to establish a multidimensional model of competence progression specific to project management. This framework segments progression into three distinct phases: foundational integration, applied execution, and strategic synthesis. In

the foundational integration phase, students are introduced to the core lexicon, methodologies, and tools of project management. Competence at this stage is characterized by the ability to correctly identify project lifecycle phases, define scope, and utilize basic scheduling software. Accordingly, calibrated assessment tasks in this phase should possess low ambiguity, high scaffolding, and rubrics focused on accuracy and procedural compliance [15]. Moving into the applied execution phase, students must navigate the messy realities of project implementation. Competence here is marked by the ability to manage team dynamics, track progress against a baseline, and apply fundamental risk responses. Assessments must therefore be calibrated to introduce moderate ambiguity, such as unexpected changes to project constraints, requiring students to demonstrate adaptability and problem-solving. Scaffolding is reduced, and rubrics shift to evaluate decision-making rationales and collaborative processes. Finally, in the strategic synthesis phase, students operate near professional entry-level standards. Competence involves aligning project outcomes with broader organizational strategy, negotiating complex stakeholder conflicts, and leading through uncertainty. Assessment tasks in this phase must be highly authentic, featuring significant ambiguity and minimal instructional scaffolding [16]. Evaluation rubrics at this stage must strictly assess leadership, strategic foresight, and the comprehensive quality of the final project deliverables.

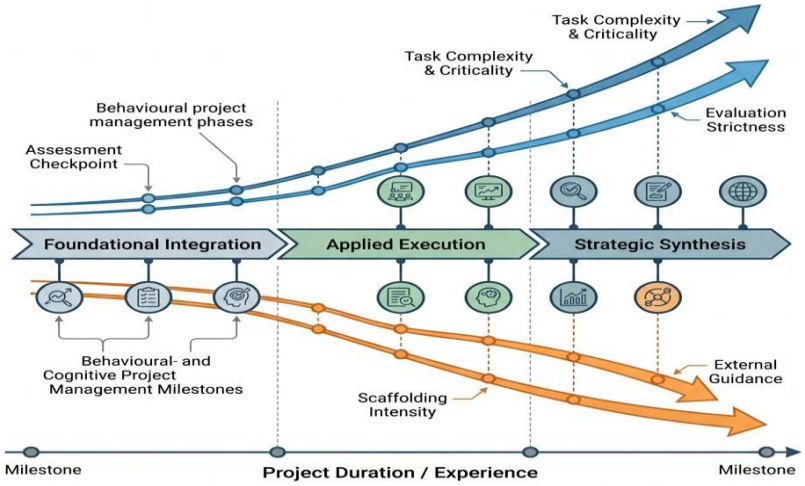


Figure 1: Comprehensive Schematic of Assessment

4. Research Methodology

4.1 Research Design

To comprehensively investigate the efficacy of assessment-task calibration in project-based management courses, this study employed a longitudinal, quasi-experimental research design supplemented by qualitative data collection. This mixed-methods approach was selected because it allows for both the robust statistical measurement of student performance trends over time and an in-depth understanding of the experiential phenomena reported by the participants [17]. The study spanned three academic years, facilitating the observation of multiple student cohorts progressing through the identical degree program. The design established a control group, which engaged with a traditional, static assessment architecture characterized by a mid-term examination and a heavily weighted final project report. Simultaneously, the experimental group was exposed to the newly developed calibrated assessment framework. In this framework, the final project was deconstructed into a series of sequentially calibrated tasks, each mapping directly to the

competence progression phases outlined in the conceptual framework. By maintaining consistency in the instructional content, faculty profiles, and overarching learning objectives across both groups, the research design isolated the assessment calibration structure as the primary independent variable. The dependent variables measured included academic performance scores, self-reported competence acquisition, and student engagement levels.

Table 1: Participant Demographics and Course Characteristics

Category	Control Cohort	Experimental Cohort	Total Sample
Undergraduate Students	145	152	297
Graduate Students	85	90	175
Average Age (Years)	22.4	22.7	-
Prior Project Experience	Low	Low	-
Total Assessments	3	8	-

4.2 Participant Selection and Context

The participant pool for this study comprised students enrolled in a comprehensive project management degree program at a large, research-intensive university. The sample included both undergraduate students in their final year of study and graduate students in the first year of their masters program. This specific demographic was selected because these students are at a critical juncture where they must transition from theoretical learning to practical application, making them ideal subjects for studying competence progression [18]. A total of 472 students participated in the study over the three-year period. Allocation to the control or experimental cohort was determined by the academic calendar year to prevent cross-contamination of assessment materials and peer-to-peer influence between the different pedagogical models. Informed consent was obtained from all participants, and the study design was approved by the institutional ethics review board. The context of the project-based course involved teams of five to six students acting as external consultants for a simulated industry client. They were required to manage a software implementation project from initiation through to handover. The complexity of the simulated project was standardized across all cohorts to ensure that the baseline difficulty of the course material remained constant [19, 20]. The faculty members involved in delivering the course underwent specific training to ensure uniform delivery of content and to familiarize themselves with the nuanced grading rubrics required for the experimental calibrated assessments.

4.3 Data Collection Instruments

Data collection relied on a triangulated set of instruments designed to capture both quantitative and qualitative dimensions of the learning experience. The primary quantitative instrument was a standardized performance evaluation matrix used by the instructional team to grade student outputs. For the control group, this matrix evaluated the final project report across standard criteria. For the experimental group, the matrix was adapted into phase-specific rubrics that measured task performance at each calibrated milestone [21]. To establish a basis for comparison, the final project outputs of both groups were evaluated by an independent panel of industry practitioners who were blind to the students cohort affiliation. This provided an objective measure of the final competence level achieved. The secondary quantitative instrument was a validated self-efficacy questionnaire administered at three points during the semester: week one, week seven, and week fourteen. This questionnaire measured students perceived competence in core project management domains, utilizing a standard Likert scale. Qualitative data was gathered through semi-structured focus group interviews conducted with a representative subset of students from both cohorts at the conclusion of the course. These interviews explored students perceptions of the assessment workload, the clarity of expectations, and the emotional trajectory of their learning experience.

Additionally, reflective journals maintained by the faculty members provided insights into the instructional challenges and administrative overhead associated with managing the calibrated assessment framework.

5. Implementation and Empirical Data Analysis

5.1 Analytical Procedures

The vast dataset generated through the multi-year study required rigorous and systematic analytical procedures to ensure validity and reliability. Quantitative data, encompassing the academic performance scores and the longitudinal self-efficacy questionnaire results, were analyzed using advanced statistical software. Independent samples t-tests were utilized to compare the mean performance scores of the final project deliverables between the control and experimental cohorts, determining if the assessment calibration had a statistically significant impact on the ultimate quality of student output [22]. To analyze the progression of self-efficacy over the three measurement points, repeated measures Analysis of Variance was employed. This technique is particularly suited for longitudinal data, allowing the researchers to identify not only differences between the groups but also the interaction effect between the assessment model and time. In essence, it highlighted whether students in the calibrated model developed confidence at a different rate than their peers in the traditional model. For the qualitative data derived from focus groups and faculty journals, a thematic analysis approach was adopted. The transcripts were systematically coded to identify recurring patterns of meaning [23]. The coding process involved an initial phase of open coding to capture broad concepts, followed by axial coding to establish relationships between these concepts, eventually leading to the definition of overarching themes related to cognitive load, feedback utility, and intrinsic motivation.

5.2 Evaluating Calibration Efficacy

The core mechanism of evaluating calibration efficacy centered on tracking the correlation between the difficulty index of the assigned tasks and the students demonstrated mastery at each phase. In the experimental cohort, the sequence of eight calibrated assessments provided a granular view of competence progression. The first two assessments, focused on foundational integration, exhibited high completion rates and strong performance scores, indicating that the low ambiguity and high scaffolding were appropriately matched to the novice stage [24, 25]. However, the critical analytical juncture occurred during the transition to the applied execution phase. Here, the instructional design deliberately increased complexity by introducing simulated project disruptions, such as unexpected budget cuts or stakeholder scope changes. Analysis of the performance data during this middle phase revealed a temporary plateau in grades, which, upon cross-referencing with the qualitative focus group data, was identified as a period of productive struggle. Students reported high levels of challenge but also noted that the progressive nature of the tasks prevented the challenge from becoming overwhelming. The analysis demonstrated that the feedback provided during this intermediate phase was rapidly integrated by the students into the subsequent tasks. By tracking the trajectory of individual student scores from the foundational tasks through to the strategic synthesis tasks, the researchers could statistically validate the alignment of the assessment architecture with the anticipated competence milestones [26].

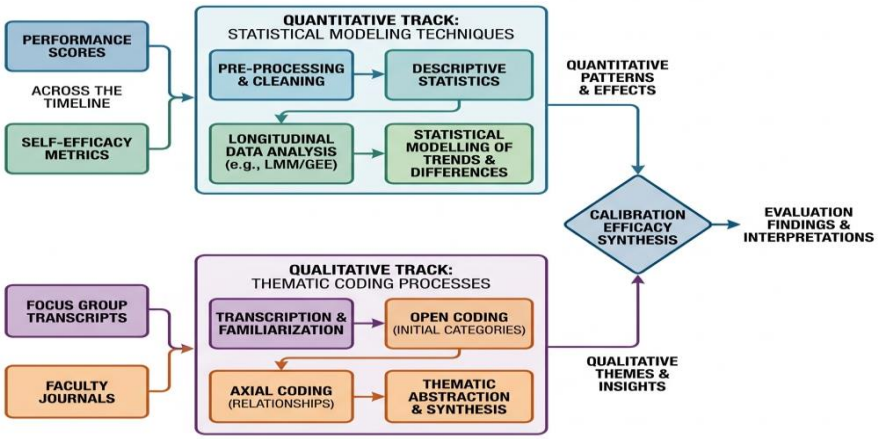


Figure 2Analytical Data Flowchart for Calibration Evaluation

6. Results and Comprehensive Discussion

6.1 Quantitative Findings on Competence Attainment

The quantitative analysis yielded compelling evidence supporting the efficacy of assessment-task calibration in project-based management courses. The independent evaluation of the final project deliverables by the blind panel of industry practitioners revealed a statistically significant difference in overall quality between the two cohorts. The experimental cohort, which engaged with the calibrated assessment framework, achieved a mean score of 84.6 out of 100, while the control cohort achieved a mean score of 76.2. This variance was particularly pronounced in the evaluation criteria related to strategic synthesis and risk mitigation, areas that require higher-order cognitive processing and practical application [27]. Furthermore, the repeated measures analysis of the self-efficacy questionnaires demonstrated a distinct developmental trajectory. While both cohorts commenced the course with similar baseline levels of perceived competence, the experimental cohort exhibited a steep and sustained increase in self-efficacy following the introduction of the intermediate calibrated tasks. In contrast, the control cohort's self-efficacy remained relatively flat during the middle of the semester, only spiking immediately prior to the final project submission. This suggests that the calibrated tasks provided continuous validation and reinforcement of learning, whereas the traditional model left students uncertain of their progress until the culmination of the course. The progressive accumulation of competence, as evidenced by both the formative task scores and the final summative evaluation, confirms that aligned task complexity serves as a powerful catalyst for skill acquisition.

Table 2Comparative Competence Attainment Scores by Domain

Competence Domain	Control Cohort Mean Score (SD)	Experimental Cohort Mean Score (SD)	p-value
Project Scoping and Planning	81.4 (5.2)	83.1 (4.8)	0.045
Risk Management and Mitigation	72.8 (6.7)	85.4 (5.1)	0.001
Stakeholder Communication	74.5 (7.1)	86.2 (5.5)	0.001

Strategic Alignment	70.1 (8.2)	82.9 (6.3)	0.001

6.2 Qualitative Insights from Stakeholders

The quantitative findings were robustly contextualized by the qualitative data gathered from student focus groups and faculty reflective journals. The thematic analysis of student transcripts revealed a strong consensus regarding the psychological benefits of the calibrated approach. A dominant theme was the concept of manageable progression. Students in the experimental cohort frequently expressed that while the course was highly demanding, the sequential nature of the tasks prevented feelings of insurmountable cognitive overload. They appreciated that early assessments rewarded fundamental understanding, which built their confidence to tackle the highly ambiguous tasks presented in the final weeks. Conversely, students from the control cohort often described the final project as a massive, intimidating hurdle, reporting significant anxiety and a tendency to divide the labor among team members rather than collaborating comprehensively. Faculty reflections provided a dual perspective. On one hand, instructors noted a profound improvement in the quality of classroom discussions and the sophistication of student questions in the experimental cohort, indicating deeper engagement with the material. On the other hand, the journals highlighted a substantial increase in the administrative and grading burden associated with managing eight calibrated assessments compared to the traditional three [28]. Faculty emphasized that while the pedagogical outcomes were superior, institutional support, such as teaching assistants or advanced grading software, is essential to make the calibrated model sustainable for large class sizes.

6.3 Pedagogical Implications

The findings of this research carry significant pedagogical implications for the design and delivery of project-based management courses. Primarily, the data advocates for a paradigm shift from assessment of learning to assessment as learning. When tasks are meticulously calibrated to the learners developmental stage, the assessment itself becomes the primary vehicle for competence acquisition. Educators must recognize that exposing novice students to highly complex, unconstrained project scenarios under the guise of authentic learning is often counterproductive. Authentic complexity must be introduced incrementally. Furthermore, the results underscore the critical importance of formative feedback. In the calibrated model, the feedback provided on early, highly scaffolded tasks acts as the foundational knowledge necessary for students to succeed in subsequent, less scaffolded tasks. Without this continuous feedback loop, calibration fails. The study also highlights the necessity of dynamic rubrics. Institutions must move away from generic grading criteria and invest time in developing specific, phase-appropriate rubrics that clearly signal to students the evolving expectations of professional competence. Finally, the demonstrated improvement in soft skills, such as stakeholder communication and risk management, suggests that calibrated assessments are particularly effective at bridging the gap between theoretical knowledge and behavioral application, addressing a major critique of traditional management education.

7. Conclusion and Future Research Directions

7.1 Summary of Contributions

This comprehensive study has rigorously examined the role of assessment-task calibration against competence progression within project-based management courses. By deconstructing the complex trajectory of managerial skill acquisition and mapping it against sequentially aligned assessment architectures, this research provides empirical validation for a highly structured instructional design approach. The central contribution of this paper is the demonstration that dynamic calibration—where task complexity gradually increases while scaffolding proportionately decreases—significantly enhances both the objective quality of student project deliverables and the students internalized sense of professional self-efficacy. The data clearly

indicates that traditional, static assessment models often fail to capture or stimulate the necessary transition from foundational knowledge to strategic, applied execution. In contrast, the calibrated framework ensures that students are consistently challenged within their zone of proximal development, fostering a deeper, more resilient mastery of both technical project management tools and critical behavioral competencies such as risk mitigation and stakeholder negotiation. Ultimately, this research offers educators and curriculum designers a robust, evidence-based methodology for transforming assessments from mere evaluative endpoints into powerful, integrated drivers of experiential learning.

7.2 Limitations and Future Work

While the findings present a compelling case for assessment-task calibration, several limitations must be acknowledged, providing clear avenues for future research. First, the longitudinal study was conducted within a single, research-intensive university context, focusing specifically on software implementation projects. Cultural and institutional variables, as well as the specific domain of the project, may influence the generalizability of the findings. Future research should replicate this study across diverse academic institutions and incorporate varied project domains, such as construction management, event planning, or social enterprise initiatives. Second, the study highlighted the significant administrative burden placed on faculty to design, administer, and grade the increased number of calibrated tasks. Future investigations must explore technological solutions, such as artificial intelligence-driven feedback systems or adaptive learning platforms, which could automate aspects of the formative assessment process, thereby making the calibrated model more scalable and sustainable for large cohorts. Additionally, further research is required to refine the measurement of affective and behavioral competences within calibrated rubrics, exploring how peer-assessment and self-reflection can be more deeply integrated into the progression model. Addressing these limitations will further solidify the theoretical foundation and practical application of assessment calibration in higher education.

References

Yang, Z., Wei, Y., Li, H., Li, Q., Jiang, L., Sun, L., ... & Peng, H. (2024, October). Adaptive differentially private structural entropy minimization for unsupervised social event detection. In Proceedings of the 33rd ACM international conference on information and knowledge management (pp. 2950-2960).

Mo, Z. (2025, May). Development of an Intelligent Retrieval and Recommendation System for Chinese Language Educational Resources Based on DNN Technology. In 2025 2nd International Conference on Intelligent Computing and Robotics (ICICR) (pp. 170-175). IEEE.

Yu, X., Wei, Y., Zhou, S., Yang, Z., Sun, L., Peng, H., ... & Yu, P. S. (2025, April). Towards effective, efficient and unsupervised social event detection in the hyperbolic space. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 39, No. 12, pp. 13106-13114).

Zhang, Z., Ren, F., Zhang, J., Su, S., Yan, Y., Wei, Q., ... & Guo, C. (2022). When behavior analysis meets social network alignment. IEEE Transactions on Knowledge and Data Engineering, 35(7), 7590-7607.

Ren, F., Zhang, Z., Zhang, J., Su, S., Sun, L., Zhu, G., & Guo, C. (2020, July). Banana: When behavior analysis meets social network alignment. In International Joint Conference on Artificial Intelligence.

Hu, J., Qi, Z., Wei, J., Chen, J., Bao, R., & Qiu, X. (2024, September). Few-shot learning with adaptive weight masking in conditional GANs. In 2024 International Conference on Electronics and Devices, Computational Science (ICEDCS) (pp. 435-439). IEEE.

Liu, X., Yu, Z., Yao, Y., Yang, K., Zeng, H., & Chen, C. P. (2026). A Comprehensive Survey of Cross-Modal Retrieval: Breaking Through Modal Barriers. ACM Computing Surveys.

Zhang, Q., Yang, M., Sun, G., Xiang, Y., Wang, S., Zhang, J., & Li, S. (2026). Representation learning accelerates the development of models for Li-ion battery health diagnostics and prognostics. Energy Storage Materials, 104897.

Ghosh, R., Jia, X., Yin, L., Lin, C., Jin, Z., & Kumar, V. (2022, November). Clustering augmented self-supervised learning: an application to land cover mapping. In Proceedings of the 30th International Conference on Advances in Geographic Information Systems (pp. 1-10).

Zhang, Y., Huang, Z., Zhao, M., Zhang, C., Lu, Y., Ji, Y., ... & Zeng, A. (2025). Learning unbiased cluster descriptors for interpretable imbalanced concept drift detection. IEEE Transactions on Emerging Topics in Computational Intelligence.

Cao, X., Tao, J., Liu, Z., Lyu, R., & Li, J. (2026). Handling Missing Data in CALL: A Data Quality-Driven Imputation Framework for Learner Analytics. Future-Adaptive Intelligence and Lifelong Systems, 1 (1).

Jia, Y., Yu, J., Liu, T., Huang, J., Mu, W., & Deng, F. (2024). Research on the matching effect of social media advertising appeal and narrative person: evidence from China. Journal of Theoretical and Applied Electronic Commerce Research, 19(4), 2980-2996.

Tan, Z., Luo, X., Liu, Y., & Zhang, Y. (2026, March). Mask the redundancy: Evolving masking representation learning for multivariate time-series clustering. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 40, No. 30, pp. 25787-25795).

Zhang, Y., Zhao, M., Jia, H., Li, M., Lu, Y., & Cheung, Y. M. (2025). Categorical data clustering via value order estimated distance metric learning. Proceedings of the ACM on Management of Data, 3(6), 1-24.

Zhou, Y., Li, L., Shi, Y., Luo, J., & Yu, B. Adaptive Behavior in Digital Nomads: An Interactive Spatial Structure Study Using Machine Learning.

Zhao, M., Feng, S., Zhang, Y., Li, M., Lu, Y., & Cheung, Y. M. (2024, October). Learning order forest for qualitative-attribute data clustering. In ECAI 2024: 27th European Conference on Artificial Intelligence, 19–24 October 2024, Santiago de Compostela, Spain–Including 13th Conference on Prestigious Applications of Intelligent Systems (PAIS 2024) (pp. 1943-1950). 1 Oliver's Yard, 55 City Road, London, EC1Y 1SP: SAGE Publications Pvt. Ltd.

Zhao, M., Huang, Z., Lu, Y., Li, M., Zhang, Y., Su, W., & Cheung, Y. M. (2026, March). Break the tie: Learning cluster-customized category relationships for categorical data clustering. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 40, No. 34, pp. 28715-28723).

Granovetter, M. S. (1973). The strength of weak ties. American Journal of Sociology, 78(6), 1360–1380.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), Knowing, learning, and instruction: Essays in honor of Robert Glaser (pp. 453–494). Erlbaum.

Li, Q., Ye, Q., Zhang, N., Zhang, W., & Hu, F. (2025). Digital-twin-enabled industrial IoT: Vision, framework, and future directions. IEEE Wireless Communications, 32(6), 173-181.

Qu, W., Shao, Y., Meng, L., Huang, X., & Xiao, L. (2024, June). A conditional denoising diffusion probabilistic model for point cloud upsampling. In 2024 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) (pp. 20786-20795). IEEE.

Zhao, J., Zhang, C., Qin, M., & Yang, P. (2025). QuantFactor REINFORCE: mining steady formulaic alpha factors with variance-bounded REINFORCE. IEEE Transactions on Signal Processing, 73, 2448-2463.

Qu, W., Wang, J., Gong, Y., Huang, X., & Xiao, L. (2025, June). An end-to-end robust point cloud semantic segmentation network with single-step conditional diffusion models. In 2025 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) (pp. 27325-27335). IEEE.

Zhang, T., Xu, J., Chen, J., Li, J., Xiao, Y., & Wang, Q. (2026). NodeJEPA: Structure-Conditioned Latent Prediction for Node-Level Graph Self-Supervised Learning. arXiv preprint arXiv:2608.04381.

Li, H., Zheng, T., Peng, Y., & BouDagher-Fadel, M. K. (2023). The fusulinids in a middle-late Permian carbonate platform (from Maokou to Wuchiapingian stage) in eastern Sichuan Basin, China. In Stratigraphy & Timescales (Vol. 8, pp. 413-435). Academic Press.

Xia, Y., & Ma, J. (2025). Grid-guided sparse Laplacian consensus for robust feature matching. IEEE Transactions on Image Processing, 34, 1367-1381.

Meng, L., Zhang, B., & Cao, L. (2026). Establishing linear cultural heritage corridors by integrating cultural and ecological values: a case study of the Jinzhong section of the Great Tea Road. Land, 15(2), 293.

Xu, Yuanchao, et al. "Reinforced data-driven estimation for spectral properties of Koopman semigroup in stochastic dynamical systems." arXiv preprint arXiv:2509.04265 (2025).