Simulation-based Learning and Project Management Certification Outcomes: Evidence from IPMA Level D Training

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Abstract: The development and assessment of project management competencies remain a persistent challenge in professional education. While competence frameworks emphasise behavioural and contextual judgement, assessment practices in entry-level certification contexts continue to rely predominantly on standardised knowledge-based examinations. At the same time, simulation-based and game-based learning approaches are increasingly used to support experiential learning, yet evidence linking such interventions to externally validated assessment outcomes remains limited. This study examines whether the inclusion of a simulation-based learning intervention in a preparatory course for the International Project Management Association (IPMA) Level D certification is associated with differences in certification examination performance. Using a quasi-experimental design, examination results for participants who completed simulation-supported training (n = 178) were compared with those of a reference cohort who completed the same course without the simulation component (n = 455). Certification exam scores were analysed across competence areas defined in the IPMA Individual Competence Baseline (ICB 4.0). The results indicate that participants in the simulation-supported group achieved higher overall examination scores, with statistically significant differences concentrated mainly in selected People and Practice competence elements. Mean scores in the Perspective area were also higher in the simulation-supported group, but the differences were not statistically significant. While the non-randomised design does not allow causal conclusions, the findings suggest an association between competence-oriented simulation-based learning and higher performance in a standardised, externally administered certification examination. The analysis focused not only on overall examination performance but also on the distribution of differences across individual competence elements. This made it possible to examine whether observed differences corresponded to the areas most directly activated by the simulation scenario. The study therefore provides evidence on the alignment between simulation design, competence frameworks, and externally administered assessment outcomes. The study contributes to e-learning research by demonstrating how simulation-based learning can be examined in relation to formal assessment outcomes within a professional certification context. It highlights the importance of aligning experiential learning design with competence frameworks while maintaining independence from existing assessment formats.

Keywords: Project management, Simulation-based learning, Simulation games, IPMA certification, Quasi-experiment

1. Introduction

Project management is a dynamic and complex discipline requiring diverse competencies, ranging from technical and strategic skills to interpersonal and behavioural capabilities. As organisations increasingly rely on structured project management methodologies to enhance efficiency and competitiveness (Martinelli and Milosevic, 2016), the role of competent project managers has become more critical than ever (Maylor, 2017). Ensuring that project managers are well-equipped with the necessary skills is a central concern for certification bodies and training institutions. Among the recognised competency frameworks, the IPMA ICB 4.0 provides a structured assessment of project management competencies through its four-level certification system (IPMA, 2015).

Traditional project management education relies heavily on theoretical instruction, case studies, and structured training programs. However, these approaches may not fully prepare individuals for the complexities and uncertainties of real-world project environments. To address this gap, simulation-based learning (SBL) has gained traction as an innovative educational tool that offers hands-on, experiential learning in a risk-free environment. Despite the growing adoption of SBL in project management training (Rumeser and Emsley, 2019), the effectiveness of such methods remains a subject of academic and practical debate. Some studies highlight the benefits of SBL in enhancing cognitive and behavioural competencies, whereas others raise concerns regarding methodological inconsistencies and the difficulty of measuring learning outcomes. The current study aims to contribute to this discourse by examining whether participation in a simulation-supported preparatory course is associated with differences in IPMA Level D certification examination outcomes.

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The structure of the paper is as follows. Section 2 provides an overview of project manager competency models, certification procedures, and the role of IPMA Level D certification. It then discusses simulation-based learning in project management education, clarifying its relationship with serious games and game-based learning, and explaining how it can be aligned with competence-oriented educational frameworks. Section 3 outlines the research methodology, including the quasi-experimental design, participant selection, data collection process, and statistical methods used to analyse associations between simulation-supported learning and certification examination outcomes. Section 4 presents the research findings, comparing exam performance between participants who followed conventional project management training and those who engaged in SBL. The results highlight the extent to which simulation-supported learning is associated with competence-oriented learning outcomes as reflected in certification examination results. Section 5 discusses the practical and theoretical implications of the findings and explores their relevance for project management training institutions, certification bodies, and professional development programs. The paper concludes with recommendations for integrating simulation games into project management education, emphasising the need for future research on long-term competency retention and adaptive learning technologies.

This study addresses the following research question:

RQ1: Is participation in a simulation-supported IPMA Level D preparatory course associated with higher certification examination performance compared with participation in the same course without the simulation component?

Two supplementary questions are also considered:

RQ2: In which IPMA ICB 4.0 competence areas and competence elements are between-group differences most pronounced?

RQ3: To what extent do the observed differences correspond to the competence areas and competence elements activated by the SBL intervention?

By investigating the role of simulation games in supporting competence-oriented learning, as reflected in certification examination outcomes, this research seeks to provide empirical insights into SBL's role in professional project management certification training. The findings of this study will contribute to the ongoing discussion of innovative learning methodologies in project management education and offer practical recommendations for training institutions and certification bodies seeking to enhance learning outcomes through digital and experiential learning.

2. Review of Literature

2.1 Project Manager Competencies

The concept of project manager competencies has evolved from prescriptive lists of tasks and knowledge areas to integrative constructs that emphasise performance, behaviour, and contextual judgment. Early approaches to project management competence were predominantly grounded in bodies of knowledge and method-oriented standards, focusing on procedural correctness and technical proficiency (PMI, 2002; Crawford, 2005). While these approaches contributed to the professionalisation of project management, they have proven insufficient to explain variations in performance among practitioners with comparable formal qualifications.

Contemporary competency research, therefore, adopts a broader and more dynamic perspective, recognising that effective project management depends not only on technical expertise but also on behavioural capabilities and the ability to interpret and respond to organisational and environmental conditions (Koi-Akrofi et al., 2024; Turner, Huemann and Keegan, 2014; Le Deist and Winterton, 2005). From this perspective, competence is understood as a context-dependent integration of knowledge, skills, and attitudes that becomes visible through action rather than declarative understanding alone. In project environments characterised by uncertainty and competing constraints, competencies are revealed through decision-making, stakeholder interactions, and adaptive behaviour (Alvarenga et al., 2020; Crawford and Pollack, 2007).

In project management, several competency frameworks have been developed to operationalise this holistic view. Comparative analyses of widely recognised standards, including those proposed by the Project Management Institute, IPMA, Association for Project Management, and Australian Institute of Project Management, indicate a recurring tripartite structure encompassing task-oriented, person-oriented, and context-oriented dimensions of competence (Koi-Akrofi et al., 2024; Ochoa Pacheco et al., 2023; Omidvar et al., 2011). Task-oriented competencies relate to planning, monitoring, and controlling project activities. Person-oriented competencies capture leadership, communication, self-regulation, and collaboration, while context-oriented competencies address governance, strategic alignment, and stakeholder environments. Despite differences in terminology, this conceptual convergence suggests a shared understanding of competent project management practice.

Among existing frameworks, the IPMA ICB 4.0 explicitly positions competence as a personal capability demonstrated through performance in real or simulated project situations (IPMA, 2015). Unlike knowledge-based certification models, the IPMA approach places stronger emphasis on behavioural indicators and contextual judgment, supported by evidence gathered through portfolios, interviews, and observed performance. This person-centred logic aligns with contemporary competence theory and is particularly relevant in educational and certification contexts where learning outcomes extend beyond the acquisition of factual knowledge (Omidvar et al., 2011).

Despite the conceptual maturity of competency frameworks, a persistent challenge remains in translating abstract competency constructs into reliable and scalable assessment mechanisms. While frameworks define what project managers should be capable of, they provide limited guidance on how to consistently measure these capabilities, especially at entry or early certification levels (Leigh et al., 2007). Standardised examinations, commonly used in certification schemes, tend to privilege knowledge recall and conceptual understanding, raising concerns about their ability to capture behavioural and contextual competencies that are central to contemporary models (PMI, 2002).

Empirical studies further indicate that not all competencies contribute equally to perceived effectiveness. Research applying the Competing Values Framework demonstrates that behavioural competencies such as creativity, engagement and motivation, efficiency, and value-based judgement differentiate higher- and lower-performing project managers across multiple dimensions of organisational effectiveness (Trivellas and Drimoussis, 2010). Similar conclusions have been drawn in international project contexts, where leadership, communication, stakeholder engagement, and adaptability consistently emerge as critical across project phases (Bashir, Maqsood and Jeong, 2021). These findings reinforce the argument that competence manifests through adaptive behaviour in the face of competing demands rather than adherence to predefined procedures.

In response to these limitations, scholars increasingly call for assessment approaches that combine standardisation with experiential evidence (Leigh et al., 2007; Omidvar et al., 2011). Simulation-based environments and other experiential learning tools are frequently proposed as mechanisms for eliciting observable competence-oriented behaviours in conditions that approximate the objective project complexity. However, empirical evidence linking such learning interventions with externally validated assessment outcomes, such as certification examinations, remains limited.

Against this backdrop, this study adopts the IPMA ICB 4.0 framework as its conceptual reference point. It examines whether simulation-based learning can support the acquisition of competencies that are subsequently reflected in standardised certification outcomes. By focusing on certification exam results as an external performance indicator, the study addresses a gap between competence-oriented educational design and conventional assessment practices, contributing to ongoing discussions on how project manager competencies can be meaningfully developed and evaluated in higher education and professional training contexts.

2.2 Simulation-based Learning in Project Management Education

Although simulation-based learning, serious games and game-based learning partly overlap in the literature, this study conceptualises the intervention primarily as simulation-based learning because its core educational mechanism is the modelling of project management decisions under dynamic constraints. In this sense, game-based learning and serious games provide a broader conceptual context, whereas simulation-based learning is the focal category used to describe the educational intervention examined in this study.

SBL has become an established approach in technology-enhanced education, particularly in domains requiring the development of complex, non-routine skills. In contrast to traditional instructional methods, simulation-based environments place learners in realistic decision situations in which they must manage resources, respond to dynamic feedback, and adapt their actions under conditions of uncertainty (Michael and Chen, 2006; Bellotti et al., 2019). This experiential character makes SBL especially relevant for professional education contexts where learning outcomes extend beyond factual knowledge to include judgment, behaviour, and situational awareness (Yaman et al., 2024).

Simulation-based games have been widely adopted in project management education to support the development of decision-making, communication, and coordination skills. Empirical and review studies indicate that project management simulations support active engagement in learning and can help learners develop and apply both technical project management competencies and behavioural skills in realistic, risk-free project scenarios (Geithner and Menzel, 2016; Jaccard, Bonnier and Hellström, 2022; Hellström, Jaccard and Bonnier, 2023). Unlike case studies or static exercises, simulations expose learners to the temporal consequences of their decisions, making explicit trade-offs among time, cost, scope, and stakeholder satisfaction.

Beyond their instructional value, serious games are increasingly seen as potential tools for formative and summative assessment. Assessment-oriented research in education highlights that complex competencies are best evaluated through integrated performance tasks rather than isolated knowledge tests (Leigh et al., 2007). In this respect, games generate rich performance data such as decision paths, resource allocation patterns, and outcome trajectories that can serve as evidence of competence-oriented behaviour. When combined with structured debriefing and reflection, these data support both learner self-assessment and instructor-led evaluation (Bellotti et al., 2019).

Despite this potential, most studies on game-based learning in project management focus primarily on learning effectiveness, learner satisfaction, or perceived competence development (Elenany and Ahmed, 2024). Far fewer investigations examine whether outcomes from SBL translate into externally validated assessment results, such as standardised examinations or certification outcomes. This gap is evident in entry-level professional certification contexts, where assessment practices remain predominantly knowledge-based despite competence-oriented learning designs.

Recent research in e-learning and professional education, therefore, calls for greater alignment between learning interventions and assessment mechanisms. Simulation-based environments are increasingly viewed not only as pedagogical tools but also as boundary objects that can connect educational practice with formal evaluation systems (Walker and Engelhard, 2014; Hellström, Jaccard and Bonnier, 2023; Özsoy, T., 2025). When learning activities are explicitly mapped to recognised competence frameworks, games can serve as a bridge between experiential learning and standardised assessment, without reducing competence to mere declarative knowledge.

Building on the view that simulation-based environments can serve as boundary objects connecting educational practice with formal evaluation systems, a central challenge in SBL research is to articulate how game experiences translate into valid, interpretable assessment evidence (Plass, Homer and Kinzer, 2015). In other words, the credibility of SBL claims depends not only on whether learners appear to improve, but on the explicit relationship between (a) intended learning objectives, (b) the game mechanics and learning processes they instantiate, and (c) the assessment evidence used to substantiate outcomes. Comprehensive accounts of SBL describe learning as emerging from integrated cognitive, motivational, affective, and sociocultural processes, suggesting that evaluation strategies should align with the underlying learning mechanisms rather than rely exclusively on post hoc declarative tests (Plass, Homer, and Kinzer, 2015).

A well-established response to this methodological challenge is embedded or stealth assessment, in which gameplay yields observable evidence of target constructs (e.g., decision quality, action sequences, problem-solving trajectories), and these indicators are mapped to competency models through transparent inference rules (Shute and Ke, 2012). This approach is particularly relevant in competency-oriented education, where intended outcomes include behavioural and judgment components that are difficult to capture through traditional examinations alone. From this standpoint, robust SBL evaluation typically requires an explicit validity argument that links design features to constructs and constructs to interpretable indicators (Shute and Ke, 2012; Tettegah, McCreery and Blumberg, 2015).

In practice, however, many professional education contexts rely on external standardised assessments (e.g., certification examinations) that cannot be readily adapted to capture nuanced in-game evidence. In such settings, the evaluation problem becomes one of construct alignment: the extent to which external measures capture the exact competency domains and cognitive processes that the simulation is designed to develop, and the extent to which test formats may underrepresent key competencies. Applied work on simulation games in blended formats highlights that credible claims require deliberate integration of learning activities, feedback, and assessment, including an explicit discussion of what counts as evidence and why (Wall and Ahmed, 2008; de Freitas, 2006).

Recent synthesis work also indicates that "assessment literacy" remains a practical barrier to wider SBL adoption, as educators often struggle to justify SBL when the chain from learning experience to defensible evidence of an outcome is not explicit (Yaman et al., 2024). Therefore, when SBL is evaluated using external examinations, methodological quality is strengthened when authors make alignment assumptions explicit, discuss likely construct underrepresentation, and position external test performance as one evidence source within a broader validity argument, an approach that directly informs how SBL can support evidence-based assessment of competence development in project management education (Shute and Ke, 2012; Yaman et al., 2024).

In the context of project management education, this perspective suggests that the value of SBL lies not only in enhancing learning experiences but also in its capacity to support evidence-based assessment of competence development. Building on the competence-oriented framework discussed in Section 2.1, the present study examines SBL as an educational intervention whose effects can be analysed using certification examination results as an external reference point. By doing so, the study contributes to ongoing discussions in e-learning research on how technology-enhanced learning designs can be meaningfully aligned with formal assessment practices.

3. Methodology

3.1 Research Design and Educational Content

The study was designed to examine whether participation in a simulation-supported preparatory course was associated with differences in IPMA Level D certification examination outcomes. Rather than testing the causal effectiveness of the intervention, the study analyses between-group differences in externally assessed certification results within an authentic professional training context.

The study adopts a quasi-experimental, intervention-based research design conducted within a formal project management training program preparing participants for the IPMA Level D certification. The research is positioned as applied educational research embedded in an authentic professional learning environment. Its purpose is to examine whether the inclusion of an SBL intervention is associated with differences in externally assessed learning outcomes.

Participants were not randomly assigned to groups, as they were naturally grouped by course enrolment. Certification examination outcomes for participants who completed the simulation-supported training were compared with those of a reference cohort that followed the same preparatory program, but without the simulation component, during the same period. This design reflects organisational and ethical constraints typical of certification-oriented education while allowing meaningful comparison of learning outcomes under comparable conditions.

3.2 Participants

The experimental group consisted of 178 participants who attended IPMA Level D preparatory courses between December 2022 and March 2024, during which the SBL intervention was implemented. The control group comprised 455 participants who attended the same course in the same time period but did not participate in the simulation activity. The comparison group was restricted to the same period as the simulation-supported group to reduce the risk of historical cohort effects and temporal changes in training or examination conditions.

All participants were candidates for entry-level project management certification and did not hold an IPMA certificate before enrolment in the course. The course content, instructional approach, and certification examination format were identical for both groups to ensure comparability. Anonymised examination results for both groups were obtained from the IPMA Poland certification examinations database after the course was completed.

3.3 Simulation-based Learning Intervention

The SBL intervention was implemented using the PM2PM computer-based project management simulation game, developed by PM2PM Ltd. This Polish company offers, among other consulting services, project management training courses, primarily to prepare applicants for the IPMA project management certification (PM2PM, Ltd., 2025).

At the start of the simulation, participants assumed the role of project managers responsible for delivering a newly assigned project. The initial planning phase involved defining project scope and timeline, allocating resources based on competency matrices, estimating costs, setting budget constraints, and identifying potential risks and mitigation strategies. Participants were provided with project documentation and competency matrices to support decision-making.

The simulation operated through an interactive digital dashboard that enabled participants to:

- assign human resources using a competency matrix (see Figure 1),
- schedule and adjust project timelines using Gantt charts (see Figure 2),
- monitor budget allocation and financial constraints, respond to emerging risks, delays, skill shortages, and cost fluctuations.

Figure 1: PM2PM game competency matrix dashboard (PM2PM, Ltd., 2025)

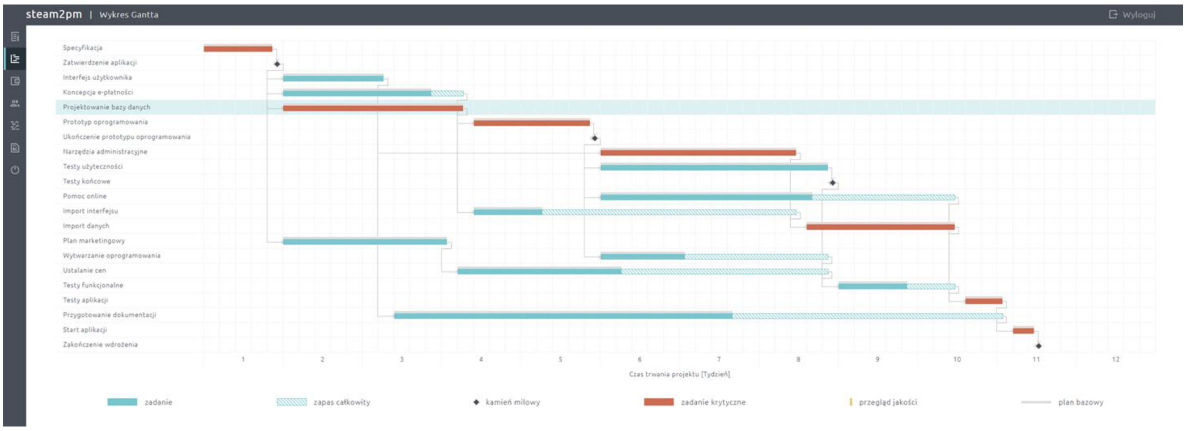

Figure 2: PM2PM game Gantt dashboard (PM2PM, Ltd., 2025)

The simulation session followed a structured timeline consisting of:

- a planning phase (approx. 45 minutes) focused on project setup, resource allocation, and budgeting,
- an execution phase (approx. 60 minutes) involving dynamic decision-making and project adjustments,
- a debriefing and evaluation phase (approx. 30 minutes) dedicated to performance analysis and reflective discussion.

During execution, the simulation dynamically modified project conditions, requiring participants to trade off cost, schedule, quality, and resource availability. Real-time feedback allowed participants to observe the consequences of their decisions and adjust strategies accordingly. At the end of the simulation, participants received performance reports summarising schedule efficiency, budget adherence, resource utilisation, risk exposure, and overall project quality.

3.4 Alignment of the Simulation with the IPMA ICB 4.0

The design of the PM2PM simulation reflects the competence-oriented logic of the IPMA ICB 4.0. Rather than addressing individual competence elements in isolation, the simulation presents integrated project scenarios that require the simultaneous application of competencies from the Perspective, People, and Practice areas.

Decision situations embedded in the simulation engage competence elements related to strategy, governance, and compliance (Perspective); teamwork, communication, and conflict management (People); and scope, time, cost, risk, and change management (Practice) (Table 1). These competences are activated through observable decision-making and interaction patterns rather than through explicit instruction or examination-style assessment.

Table 1: Learning objectives of the PM2PM game aligned with the IPMA ICB 4.0

Area	ICB Competence Element (CE)	PM2PM Game Learning Objective
4.3 Perspective	4.3.1. Strategy	
	4.3.2. Governance, structures, and processes	
	4.3.3. Compliance, standards, and regulations	
	4.3.4. Power and interest	
	4.3.5. Culture and values	
4.4 People	4.4.1. Self-reflection and self-management	
	4.4.2. Personal integrity and reliability	
	4.4.3. Personal communication	X
	4.4.4. Relationships and engagement	
	4.4.5. Leadership	X
	4.4.6. Teamwork	X
	4.4.7. Conflict and crisis	
	4.4.8. Resourcefulness	
	4.4.9. Negotiation	
	4.4.10. Result orientation	
4.5 Practice	4.5.1. Project design	
	4.5.2. Requirements and objectives	X
	4.5.3. Scope	X
	4.5.4. Time	X
	4.5.5. Organisation and information	
	4.5.6. Quality	X
	4.5.7. Finance	X
	4.5.8. Resources	X
	4.5.9. Procurement	
	4.5.10. Plan and control	X
	4.5.11. Risk and opportunity	X
	4.5.12. Stakeholders	X
	4.5.13. Change and transformation	

Importantly, the simulation was not designed to replicate the structure or content of the IPMA certification examination and did not function as direct exam preparation. Its purpose was to operationalise competence development by creating conditions in which conceptual knowledge acquired during the course had to be applied in dynamic, uncertain project contexts. The alignment with IPMA ICB 4.0, therefore, exists at the level of competence domains and behavioural manifestations rather than at the level of exam items or scoring criteria.

3.5 Assessment Measures and Data Collection

The primary outcome measure in the study was performance on the IPMA Level D certification examination, a standardised, externally administered assessment aligned with IPMA ICB 4.0. The examination is conducted independently of the training provider and researchers. For both experimental and control groups, anonymised examination results were collected after course completion. The dataset included overall certification exam scores and competence element scores aggregated within the Perspective, People, and Practice areas, as reported in official examination records. No in-game performance metrics or self-reported learning measures were used as dependent variables. The study deliberately focused on externally validated assessment outcomes to ensure comparability across cohorts and to avoid bias associated with internally generated performance indicators.

3.6 Ethical Considerations

Participation in the study was voluntary and did not affect access to training or certification. Examination data were analysed in an anonymised form and used exclusively for research purposes. The study adhered to institutional guidelines for educational research and data protection.

The authors declare no commercial affiliation with the simulation provider.

4. Research Results

All data were analysed using SPSS v. 29. The data were first examined for skewness and kurtosis, and no problematic issues were noted (skewness and kurtosis in between –1 and 1). An independent-samples t-test was performed for each competence element to examine differences in exam scores between the experimental (n = 178) and control (n = 455) groups. Cohen's d was used to assess the magnitude of observed between-group differences. Given the exploratory nature of competence-element-level comparisons, p-values are interpreted descriptively and reported alongside effect sizes. The emphasis is placed on the overall pattern of differences rather than on isolated statistically significant results.

4.1 Perspective Area

Across all five competence elements in the perspective area, the average scores were higher among individuals who completed the simulation game; however, no statistically significant differences were observed for any of these elements (Table 2). The negative values of Cohen's d indicate that the mean results in the experimental group were higher than in the control group. The higher the Cohen's d values, the bigger the differences between the two analysed groups.

Table 2: Scores for the competence elements in the perspective area

ICB CE	Mean 1	Mean 2	SD 1	SD 2	Sig.		Cohen's *d*	RANK
Power and interest	3.84	3.97	1.325	1.244	0.140		-0.096	
Strategy	3.40	3.52	1.272	1.272	0.145		-0.094	
Governance, structures, and processes	3.97	4.04	1.119	1.005	0.226		-0.066	
Culture and values	4.38	4.39	1.020	0.946	0.422		-0.017	
Compliance, standards, and regulations	3.72	3.74	1.149	1.020	0.426		-0.017	

4.2 People Area

The statistically significant difference was observed in three out of 10 competence elements belonging to the people area, with the highest differences occurring for teamwork (M1 = 3.70; M2 = 4.09; $p < 0.001$, d = -0.324), followed by relationships and engagement (M1 = 4.23; M2 = 4.49; p = 0.001, d = -0.240), result orientation (M1 = 3.94; M2 = 4.10; p = 0.041, d = -0.144). The analysis results are summarised in Table 3.

Table 3: Scores for the competence elements in the people area

ICB CE	Mean 1	Mean 2	SD 1	SD 2	Sig.		Cohen's *d*	RANK
Teamwork	3.70	4.09	1.137	1.075	<0.001	***	-0.324	1
Relationships and engagement	4.23	4.49	1.155	0.916	0.001	***	-0.240	2
Result orientation	3.94	4.10	1.153	0.978	0.041	*	-0.144	3
Personal communication	4.34	4.48	1.005	0.891	0.104		-0.144	
Conflict and crisis	3.97	4.01	1.046	1.031	0.316		-0.042	
Leadership	3.68	3.74	1.301	1.307	0.325		-0.040	
Resourcefulness	4.37	4.40	1.000	0.929	0.352		-0.034	
Self-reflection and self-management	4.47	4.50	0.947	0.885	0.379		-0.027	
Negotiation	4.02	4.04	1.120	0.965	0.410		-0.020	
Personal integrity and reliability	3.91	3.80	1.186	1.147	0.136		0.097	

4.3 Practice Area

In the practice area, a statistically significant difference was observed in 5 of 13 cases, with the largest effect observed for change and transformation (M1 = 3.40; M2 = 3.81; $p < 0.001$, d = -0.311), followed by scope (M1 = 3.77; M2 = 4.08; p = 0.002, d = -0.241) and resources (M1 = 4.01; M2 = 4.26; p = 0.001, d = -0.225). The analysis results are presented in Table 4.

Table 4: Scores for the competence elements in the practice area

ICB CE	Mean 1	Mean 2	SD 1	SD 2	Sig.		Cohen's *d*	RANK
Change and transformation	3.40	3.81	1.367	1.264	<0.001	***	-0.311	1
Scope	3.77	4.08	1.319	1.152	0.002	**	-0.241	2
Resources	4.01	4.26	1.150	0.992	0.001	**	-0.225	3
Finance	3.93	4.12	1.282	1.126	0.006	**	-0.153	4
Project design	3.62	3.82	1.308	1.254	0.042	*	-0.153	5
Procurement	4.00	4.12	1.215	1.168	0.114		-0.107	
Time	3.48	3.63	1.232	1.158	0.071		-0.130	
Risk and opportunity	2.89	3.03	1.471	1.424	0.135		-0.098	
Plan and control	3.85	3.96	1.278	1.234	0.165		-0.086	
Requirements and objectives	3.20	3.26	1.304	1.272	0.301		-0.046	
Organisation and information	4.15	4.17	1.131	1.028	0.414		-0.019	
Stakeholders	3.63	3.64	1.403	1.321	0.468		-0.007	
Quality	3.48	3.42	1.282	1.330	0.284		0.051	

4.4 Overall IPMA Level D Exam Scores

The last step of the analysis was to compare the overall exam scores of the two groups. According to the independent-samples t-test results, there is a significant difference in exam scores between the two analysed groups (N1 = 455, N2 = 178). The simulation-supported group achieved significantly higher overall exam scores than the comparison group (M1 = 107.34; M2 = 110.54; p = 0.02, d = -0.181). The analysis results are presented in Table 5.

Table 5: Overall exam scores for the two analysed groups

Mean 1	Mean 2	SD 1	SD 2	Sig.		Cohen's *d*
107.34	110.54	18.614	15.116	0.02	**	-0.181

Thus, the quasi-experimental analysis indicates an association between participation in simulation-supported learning and higher performance in the IPMA Level D certification examination. Across the IPMA Level D examination results, statistically significant differences between the simulation-supported and comparison cohorts were observed for a substantial subset of competence elements. The significant differences were identified in the People and Practice competence areas, particularly in elements related to teamwork, relationships and engagement, change, scope, resource and finance, with effect sizes ranging from small to moderate (highest Cohen's d ≈ 0.3-0.35). Differences within the Perspective area were generally weaker and not significant. At the overall examination performance level, the simulation-supported cohort achieved significantly higher scores with reduced score dispersion, indicating more homogeneous outcomes.

5. Discussion and Conclusions

5.1 Discussion

This study aimed to examine whether the inclusion of an SBL activity within a certification-oriented project management course is associated with differences in externally assessed learning outcomes. By focusing on certification examination results rather than self-reported learning gains, the study addresses a significant gap between competence-oriented educational design and predominantly knowledge-based assessment practices in professional education.

The results indicate that participants who completed the simulation-supported training achieved higher overall certification examination scores, with statistically significant differences concentrated in selected People and Practice competence elements. Although mean scores in the Perspective area were also higher in the simulation-supported group, these differences were not statistically significant. This pattern suggests that the association between simulation-supported learning and examination performance was not evenly distributed across all IPMA ICB 4.0 competence areas. Instead, the biggest differences appeared in competence elements that were more directly activated by the simulation scenario, particularly those related to teamwork, relationships and engagement, change and transformation, scope, resources, finance, and project design.

This distribution of results is consistent with the internal logic of the simulation-based learning intervention. During the simulation, participants were required to define the project scope, allocate resources, estimate and monitor costs, respond to emerging constraints, and adjust project decisions as conditions changed. These activities correspond closely to selected Practice competences, especially scope, resources, finance, project design, and change and transformation. At the same time, the collaborative and decision-oriented nature of the simulation may explain the observed differences in selected People competences, particularly teamwork, relationships, and engagement. By contrast, Perspective competences concern broader organisational, strategic, and contextual aspects of project management, such as governance, compliance, power structures, and culture. These elements were less directly represented in the simulated project environment, which may explain why differences in this area were weaker and not statistically significant.

The findings therefore suggest that simulation-based learning may be particularly useful for supporting competence-oriented learning in areas where learners must integrate technical project management decisions with interpersonal coordination and adaptive judgement. However, the results should not be interpreted as evidence that participation in the simulation-supported course was associated with higher performance across all competence areas equally. Rather, they indicate a selective association between participation in the simulation-supported course and higher performance on the competence elements most closely aligned with the decision-making tasks embedded in the simulation.

From an e-learning perspective, the study supports the view that simulation-based environments can function as a bridge between experiential learning and formal assessment systems. Although certification examinations are limited in their ability to directly capture behavioural and contextual competence, the results indicate that learning designs grounded in dynamic decision-making, feedback, and reflection may also be reflected in externally administered assessment outcomes. This is particularly relevant in professional education contexts where external certification bodies define assessment formats and cannot be easily modified by educators or training providers.

The magnitude of the observed differences should be interpreted cautiously. The overall difference in examination scores was statistically significant, but the effect size was small. This is consistent with expectations for applied educational interventions implemented in authentic professional training settings, where participants differ in prior experience, motivation, learning strategies, and professional background. The relatively small effect sizes also reinforce the need to interpret the findings as evidence of association rather than as strong evidence of causal impact.

The study contributes to the existing body of knowledge in three main ways. First, it extends research on simulation-based learning by examining externally validated certification examination outcomes rather than relying solely on learner satisfaction, perceived competence development, or in-game performance data. Second, it contributes to project management education by demonstrating how a simulation-based intervention can align with a recognised professional competence framework, namely IPMA ICB 4.0. Third, it contributes to e-learning assessment research by illustrating both the potential and the limitations of evaluating experiential learning interventions through standardised assessment systems that were not originally designed to measure behavioural competence directly.

Taken together, the findings contribute to ongoing discussions on competence development and assessment in project management education. While competence frameworks such as IPMA ICB 4.0 emphasise demonstrated ability in action, entry-level certification assessments remain largely knowledge-based. The present study illustrates a pragmatic approach to this tension by examining whether competence-oriented learning designs can be reflected, at least partially, in existing assessment systems without altering certification formats. At the same time, the selective pattern of significant results highlights the importance of carefully aligning simulation design, intended learning outcomes, and assessment evidence when evaluating simulation-based learning in professional certification contexts.

5.2 Limitations and Directions for Future Research

Several limitations of the study should be acknowledged. First, the quasi-experimental design without random assignment limits causal interpretation. Although the comparison group was restricted to the same period as the simulation-supported group to reduce the risk of historical cohort effects and temporal changes in training or examination conditions, unmeasured differences in prior project management experience, motivation, learning strategies, or professional background may have influenced the results. Therefore, the findings should be interpreted as evidence of association rather than as definitive evidence of causal impact.

Second, the study did not include a pre-test, which restricts the ability to control for baseline differences between groups. Without pre-intervention measures of project management knowledge or competence, it is not possible to determine whether the observed between-group differences resulted from the simulation-supported learning activity or from pre-existing differences between participants.

Third, the groups differed in size. Although unequal group sizes do not invalidate the analysis, they may affect the precision of estimates and reinforce the need to interpret statistical significance together with effect sizes. In this study, the overall effect size was small, and the competence-element-level effects ranged from small to moderate. These results should therefore be interpreted cautiously, with attention to the overall pattern of differences rather than to isolated statistically significant results.

Fourth, certification examination results were used as the sole outcome measure. While this choice strengthens external validity and comparability across groups, it does not capture behavioural performance during the simulation, reflective learning processes, learner engagement, or longer-term transfer of competence to professional practice. Moreover, because the IPMA Level D examination is an externally administered standardised assessment, it may underrepresent some behavioural and contextual aspects of competence that simulation-based learning is designed to develop.

Finally, because multiple competence-element-level comparisons were conducted, the results should be interpreted as exploratory and pattern-oriented rather than as confirmatory evidence for isolated competence elements. Future research could address these limitations by combining externally validated assessment outcomes with in-simulation performance data, reflective artefacts, learner feedback, or longitudinal follow-up measures. Where feasible, randomised, matched-group, or crossover designs would further strengthen causal inference. More fine-grained analysis of the relationship between specific simulation design features and particular IPMA ICB 4.0 competence elements may also provide deeper insight into the mechanisms through which simulation-based learning supports competence development.

5.3 Conclusions

This study contributes to e-learning research by demonstrating how SBL can be examined in relation to externally validated assessment outcomes within a professional certification context. By explicitly aligning simulation design with a recognised competence framework while maintaining independence from the certification assessment itself, the study offers a methodological approach for investigating experiential learning in environments governed by external evaluation standards.

The findings indicate that simulation-supported learning is associated with higher and more consistent performance on certification examinations, particularly in competence areas that require integrative judgement and interaction. While these results do not establish causality, they provide empirical support for aligning competence-oriented learning designs with formal assessment systems.

For educators and program designers, the study highlights SBL's potential to enhance certification-oriented training without modifying existing assessment frameworks. For researchers, it underscores the value of analysing technology-enhanced learning interventions through the combined lenses of learning design, competence frameworks, and assessment alignment.

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Ethics Statement: Ethical approval was not required because the study used anonymised archival examination data. The simulation-based activity was part of regular course delivery and was not introduced solely for research purposes. The analysis did not involve identifiable personal data and had no impact on participants' certification outcomes.

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