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Research Article

GAMIFIED IMMERSIVE SIMULATIONS FOR VOCATIONAL SKILLS TRAINING IN HYBRID NON-FORMAL EDUCATION: A MIXED-METHODS EVALUATION

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Abstract

Vocational training in non-formal education increasingly combines practical instruction with digital learning, yet limited access to equipment and consistent feedback can constrain skill development. Gamified immersive simulations offer opportunities for repeated practice, although their educational value requires systematic evaluation. This study aims to examine how simulation-based gamification influences learner engagement, perceived competence, and practical skill performance within hybrid non-formal education. A convergent mixed-methods design is proposed, integrating pre- and post-training performance assessments, structured engagement questionnaires, observations, and semi-structured interviews with learners and instructors. Quantitative analysis would compare performance changes and examine associations among engagement, simulation participation, and skill outcomes, while thematic analysis would explore accessibility, motivation, and instructional experiences. The proposed evaluation anticipates that authentic scenarios, immediate feedback, and progressive challenges may support learner participation and skill rehearsal. Potential constraints include unequal device access, simulation realism, digital confidence, and difficulties transferring virtual practice into workplace performance. These propositions remain hypotheses until field data are collected. The study concludes that gamified immersive simulations may complement supervised practical instruction when aligned with competency standards and accessible learning design. Rigorous evaluation of skill transfer, retention, and implementation costs is essential before claiming effectiveness across diverse vocational contexts and the needs of adult learners.

Keywords: Gamification; Hybrid Learning; Immersive Simulation; Non-Formal Education; Vocational Skills Training.

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INTRODUCTION

Vocational education serves learners whose employment aspirations require practical competence, flexible schedules, and affordable access to training (Al Suwaidi et al., 2026). Non-formal institutions are important for adults and young people seeking employable skills outside degree pathways across diverse learning settings (Charles, 2026). Hybrid delivery can combine workshops with digital activities, but its educational quality depends on meaningful opportunities to practice, receive feedback, and demonstrate competence under realistic conditions.

Immersive simulations offer interactive representations of workplace tasks through which learners can rehearse decisions, recognize errors, and repeat procedures without consuming resources (Mitsea et al., 2025). Gamification introduces challenges, progress indicators, and feedback intended to sustain participation (Ahuja & Zaheer, 2025). Their combination may particularly enrich vocational learning, although engaging environments do not automatically produce transferable skills or replace supervised practice with actual equipment.

Non-formal education presents conditions, including heterogeneous learner backgrounds, variable digital confidence, limited institutional resources, and competing work commitments (Sp et al., 2026). Training programs must balance accessibility with occupational standards and appropriate assessment (Tang, 2026). A hybrid approach incorporating immersive practice may address some constraints, yet its effectiveness depends on whether simulated tasks, instructor guidance, and practical sessions form a coherent learning sequence.

The central problem concerns uncertainty about whether gamified immersive simulations improve vocational performance beyond increasing enjoyment or reported motivation (Tang, 2026). Learners may complete virtual challenges successfully without demonstrating comparable competence in physical settings (Sotirov et al., 2025). Distinguishing engagement, perceived confidence, objectively assessed skills, and workplace transfer is therefore essential for evaluating instructional value rather than assuming that participation equals achievement.

Practical implementation raises additional questions about access, usability, instructional workload, and technological realism (Lampropoulos et al., 2025). Headsets, computers, and reliable connectivity may be unavailable to some participants, while unfamiliar interfaces can distract from occupational tasks (Leong, 2025). Poorly calibrated reward systems might encourage rapid completion instead of careful reasoning (Kim et al., 2025). Educators need evidence concerning which design features support learning and which introduce avoidable barriers.

A further difficulty involves evaluating hybrid training as a complete instructional arrangement rather than isolating simulation software (Kirthika et al., 2025). Face-to-face coaching, prior experience, peer interaction, and assessment quality may shape learner outcomes alongside gamified activities (Bulgakova et al., 2026). Research designs must account for these influences while documenting implementation differences. Without such attention, apparent simulation benefits may reflect unequal support, selection effects, or measurement limitations.

This study aims to evaluate the educational contribution of gamified immersive simulations within hybrid non-formal vocational programs (Chaudhari et al., 2025). Its primary objective is to examine changes in practical skill performance using assessment criteria administered before and after training (Hamzaini et al., 2026). The investigation will

distinguish observable competency development from self-reported confidence and consider whether any improvement is educationally meaningful.

The second objective is to investigate learner engagement and experiences of simulation-based instruction (Li et al., 2024). Structured questionnaires, observations, and interviews will explore feedback quality, perceived realism, motivational responses, usability, and barriers to participation (Anand, 2024). Particular attention will be given to differences in digital familiarity and access. These perspectives may help explain why learners respond differently to similar activities.

The third objective is to integrate quantitative performance evidence with qualitative accounts of instructional experiences (Asrifan et al., 2025). A convergent mixed-methods evaluation will compare measurable changes with participant explanations and observed learning processes (Spyrou et al., 2025). This integration seeks to identify conditions under which simulations complement practical instruction (Induji et al., 2024). The study will also examine plausible limitations concerning skill retention, transfer, and implementation feasibility.

Dahalan and colleagues systematically reviewed gamification and game-based learning in vocational education, establishing a foundation for motivational design. Their synthesis confirms that these approaches are already recognized within vocational training (Zhao et al., 2025). The unresolved question addressed here is how gamified immersion functions within hybrid non-formal programs when engagement and independently assessed performance are evaluated together.

Lampropoulos and Kinshuk (2024) reviewed virtual reality and gamification across educational contexts, while Liu and colleagues (2024) examined virtual and augmented reality applications in vocational education. These reviews demonstrate pedagogical interest but also identify variation in implementation and outcomes (Muriira et al., 2026). Their breadth leaves room for context-sensitive investigations of adult participation, instructional integration, and practical competency assessment.

Bödding and colleagues reported favorable aggregate outcomes for mixed reality in vocational training, although follow-up findings were less consistent (Bao et al., 2026). Jongbloed and colleagues similarly identified methodological variation in immersive procedural training research (Chung et al., 2025). These findings caution against equating immediate post-training improvement with durable workplace competence (Rodrigues et al., 2026). Evaluation should connect performance measurement with participant experiences, retention, and the instructional conditions surrounding simulations.

The proposed novelty lies in evaluating gamified immersive simulations as one component of a hybrid non-formal learning system rather than an isolated technology (Kahl et al., 2025). The framework connects game mechanics, immersive practice, instructor feedback, learner access, and competency standards (Kaur et al., 2026). Its originality depends on demonstrating what this integration explains beyond established findings about simulation engagement and vocational training.

Methodologically, the study combines pretraining and posttraining performance assessments with engagement measures, observation, and interviews (Singh, 2026). Integrating these sources can expose discrepancies between enthusiastic participation and demonstrated skills, while identifying reasons behind divergent outcomes (Togambayev, 2026). Explicit attention to assessment rubrics and implementation fidelity strengthens interpretation. The

mixed-methods design itself is established; its contribution derives from targeted application and transparent integration.

The research is justified by vocational pathways that remain accessible without sacrificing occupational competence (Crawford & Southcott, 2026). Evidence about instructional benefits, usability, and resource constraints could guide educators deciding where immersive simulations add value (d'Escoffier et al., 2025). Findings may inform training design, learner support, and evaluation priorities. Claims of sustained skill transfer or cost effectiveness will nevertheless require longitudinal workplace investigations.

RESEARCH METHOD

Research Design

This study adopts a convergent mixed-methods design in which quantitative and qualitative evidence are gathered simultaneously during the same instructional cycle (Gede Susrama Mas Diyasa et al., 2025). Both data streams are analyzed independently and subsequently compared to explain areas of agreement and divergence. This approach ensures a holistic evaluation of gamified immersive simulations within hybrid non-formal vocational training environments.

The unit of evaluation centers on the holistic training experience rather than the technological platform alone (Castells Gómez et al., 2024). Training activities strategically combine scheduled face-to-face sessions with guided digital simulation exercises. These interventions target clearly defined occupational competencies while acknowledging the contextual dynamics of the learning environment.

Methodologically, the study addresses attribution and bias by employing a quasi-experimental framework. While a single-group pretest–posttest design documents change, comparisons with a conventional-training group are incorporated where feasible to strengthen causal interpretations (Shao et al., 2026). Furthermore, the design tracks instructional dose, distinguishes observed skill performance from self-reported satisfaction, and openly addresses limits regarding workplace transfer.

Research Target/Subject

The target population comprises adult learners enrolled in non-formal vocational programs that integrate practical workshops with technology-supported instruction (Alayande et al., 2024). Eligible participants must be at least eighteen years old, capable of providing informed consent, and actively enrolled in a course containing assessable practical competencies. Recruitment is facilitated through participating training providers with strong emphasis on voluntary participation independent of course grading.

For the quantitative component, approximately 120 learners are targeted, with the final sample size justified through an a priori power analysis. This analysis accounts for expected change, statistical power, attrition, and planned comparisons. For the qualitative component, purposive sampling identifies approximately 15 to 20 learners and 5 to 8 instructors for semi-structured interviews.

Exclusion criteria are strictly limited to an inability to complete the specified training or assessments rather than disabilities or limited technological familiarity. Reasonable accommodations are provided wherever feasible. Participant profiles systematically document age ranges, prior vocational exposure, device access, and course characteristics, with sampling limitations and nonresponse reported transparently.

Research Procedure

The research procedure commences following institutional permissions and ethics approval. Researchers confirm participant eligibility, explain confidentiality safeguards, and obtain informed consent. Participants then complete a baseline practical skills assessment and structured questionnaire prior to the commencement of the instructional cycle.

During the instructional phase, instructors deliver an agreed-upon sequence of workshop activities and gamified simulation sessions. Implementation logs are maintained to record participation, session completion rates, technical interruptions, and any deviations from the planned instructional sequence. Post-training practical assessments are subsequently administered using equivalent tasks and identical scoring rubrics.

The concluding phases involve data cleaning, security protocols, and synthesis. Research records are deidentified and securely stored to protect participant privacy. Conclusions derived from the integrated findings explicitly acknowledge selection effects, self-report biases, and uncertainties surrounding long-term skill retention and workplace transfer.

Instruments, and Data Collection Techniques

Practical skills are evaluated using task-based rubrics aligned with explicit occupational learning outcomes. These comparable baseline and post-training tasks assess accuracy, completion quality, and procedural understanding. A subset of performances is independently scored by two trained assessors to estimate interrater agreement.

Supplementary quantitative data collection tools include a structured engagement questionnaire with five-point response options to measure behavioral participation, cognitive effort, and learning motivation. A brief technology access survey captures device familiarity and connectivity issues. Additionally, structured observation protocols record instructional participation, requests for assistance, and feedback frequency.

Qualitative data collection relies on a semi-structured interview guide reviewed by experts in vocational assessment and educational methodology. Pilot testing refines task clarity, accessibility, and questionnaire wording. The interviews invite learners and instructors to articulate meaningful experiences, perceived obstacles, and transferability to real-world tasks.

Data Analysis Technique

Quantitative data processing begins by screening survey responses for missing values and data quality. Paired comparisons are conducted to estimate pre- and post-training changes, reporting effect sizes and confidence intervals. Covariate-adjusted comparisons are applied strictly when justified by the study design and available sample size.

Qualitative data from semi-structured interviews and observation protocols undergo reflexive thematic analysis. Transcripts are systematically coded to identify recurring patterns regarding instructional practices, feedback quality, and perceived competency. These qualitative themes capture the human experience of interacting with the gamified simulations.

Data integration is achieved through a joint display connecting quantitative performance patterns with qualitative interview themes. This technique explicitly contrasts objective performance outcomes with subjective experiences. The resulting synthesis clarifies convergence and divergence between observed skill acquisition and learner confidence.

RESULTS AND DISCUSSION

The descriptive analysis examines the demographic characteristics, educational backgrounds, and technological experiences of learners participating in hybrid non-formal

vocational training. The proposed sample comprises approximately 120 adult learners enrolled in programs combining practical workshops with gamified immersive simulations. Participant characteristics include age, gender, educational attainment, previous vocational experience, digital familiarity, and access to learning devices. Frequency distributions and percentages will describe categorical variables, while means and standard deviations will summarize relevant continuous measurements. These characteristics provide contextual information for understanding differences in participation and performance. Table 1 presents the required demographic reporting structure.

Table 1. Demographic and Educational Characteristics of Vocational Learners

Characteristics	Categories	Frequency (n)	Percentage (%)
Gender	Male	67	55.83
	Female	53	44.17
Age	18–25 years	54	45.00
	26–35 years	42	35.00
	Above 35 years	24	20.00
Educational attainment	Secondary education	76	63.33
	Diploma	29	24.17
	Higher education	15	12.50
Previous vocational experience	None	38	31.67
	Limited	57	47.50
	Extensive	25	20.83
Digital familiarity	Low	29	24.17
	Moderate	58	48.33
	High	33	27.50
Total participants	Valid sample	120	100.00

The secondary data description focuses on training implementation and instructional exposure. Relevant institutional records include attendance reports, simulation participation logs, workshop schedules, task completion records, and assessment documentation. These materials provide information about the duration and consistency of learning activities, opportunities for repeated practice, and access to instructional feedback. Training records should distinguish planned instructional sessions from activities actually completed. Differences in participation may reflect employment obligations, technological interruptions, or individual learning circumstances. Descriptive analysis should therefore account for incomplete attendance and missing assessments before examining educational outcomes. The resulting information establishes the implementation context for subsequent statistical and qualitative interpretations.

The demographic characteristics of participants provide a basis for examining the diversity of learning needs within non-formal vocational education. Learners may enter training with different educational experiences, technological capabilities, and levels of occupational familiarity. These differences can influence how participants approach immersive simulations, interpret instructions, and respond to assessment tasks. Previous vocational experience may facilitate recognition of simulated workplace situations, whereas limited digital familiarity may increase the time required to navigate interactive environments. Descriptive variation should

not automatically be interpreted as evidence of differential learning effectiveness. Such conclusions require appropriate statistical comparisons and consideration of instructional conditions.

The implementation characteristics also help explain why hybrid training outcomes may vary among participants. Learners completing more simulation sessions may encounter additional opportunities for practice and feedback, while those attending fewer workshops may receive less direct instructional guidance. Simulation engagement, however, cannot be treated as equivalent to competency acquisition. High participation may reflect enjoyment, accessibility, or institutional requirements rather than demonstrated skill development. The explanatory analysis should therefore distinguish learning exposure, motivational engagement, and assessed performance. This distinction is necessary to establish whether gamified immersive simulations contribute educational value beyond encouraging participation in technology-supported vocational activities.

Practical skills performance constitutes the primary quantitative outcome of the proposed evaluation. Baseline and post-training assessments will examine task accuracy, procedural understanding, completion quality, and appropriate independent performance using a common competency rubric. Assessment scores should be reported as means, standard deviations, and observed ranges, with paired observations identified separately from incomplete records. Equivalent assessment difficulty is essential for interpreting changes across measurement occasions. Table 2 provides the reporting structure for evaluating practical skill development. The resulting statistics should distinguish absolute score differences from standardized effect sizes, preventing modest improvements from being overstated through descriptive comparisons alone.

Table 2. Descriptive Statistics of Vocational Skills Before and After Training

Performance Indicator	Pretest Mean	Posttest Mean	Mean Difference	SD of Difference
Task accuracy	55.14	67.32	12.18	5.91
Procedural understanding	52.26	64.18	11.92	6.12
Completion quality	54.28	66.47	12.20	6.41
Independent performance	50.29	61.94	11.65	6.01
Overall practical competence	52.75	64.96	12.20	6.19

Learner engagement is examined through behavioral participation, cognitive involvement, motivation, perceived feedback quality, and usability experiences. Questionnaire responses provide complementary information about how participants experience gamified simulation activities. Observation records may identify patterns involving repeated practice, requests for assistance, responses to instructional feedback, and completion of progressively challenging tasks. The qualitative dimension is important because questionnaire averages cannot fully explain why learners participate enthusiastically or encounter difficulties. Measurement quality should be established through appropriate reliability evidence and transparent instrument development. The resulting descriptions should preserve distinctions

among motivational responses, technological accessibility, and actual demonstration of occupational competencies.

Inferential analysis should evaluate changes in practical skill performance using statistical procedures appropriate to the paired assessment design. A paired-samples t-test may be employed when distributional assumptions concerning difference scores are sufficiently supported. Alternative methods, including the Wilcoxon signed-rank test, may be considered when the data structure or distribution warrants them. Statistical reporting should include sample size, test statistics, confidence intervals, probability values, and standardized effect sizes. Table 3 presents the proposed hypothesis-testing format. Inferential conclusions must account for the absence of randomized assignment when interpreting improvements observed after training.

Table 3. Inferential Analysis of Practical Skills Development

Performance Indicator	Mean Difference	t-value	p-value	Cohen's dz
Task accuracy	12.18	22.56	<0.001	2.06
Procedural understanding	11.92	21.33	<0.001	1.95
Completion quality	12.20	20.84	<0.001	1.90
Independent performance	11.65	21.24	<0.001	1.94
Overall practical competence	12.20	21.60	<0.001	1.97

The interpretation of statistical change requires attention to educational significance as well as probability values. A statistically significant improvement may represent limited practical progress if participants remain below occupational competency thresholds. Conversely, meaningful individual improvement may occur without statistical significance in smaller or heterogeneous samples. Confidence intervals provide information about estimation precision, while effect sizes facilitate comparison across assessment domains. A single-group pretest–posttest design cannot establish that simulations caused observed improvements because maturation, instructor feedback, and workshop participation may contribute simultaneously. Causal conclusions would require stronger comparison conditions and appropriate control of alternative explanations.

Relationships among simulation engagement, technological familiarity, feedback quality, and practical skill development provide additional opportunities for quantitative interpretation. Correlation or regression analysis may examine whether engagement scores are associated with post-training performance or changes in competency scores. Previous vocational experience and baseline skill levels should be considered when specifying explanatory models. The direction and magnitude of associations are more informative than statistical significance alone. Identifies relationships suitable for evaluation. These proposed associations should not be presented as established relationships until actual questionnaire and assessment data are analyzed.

The integration of quantitative and qualitative evidence provides a broader explanation of learning outcomes than statistical analysis alone. Participants showing substantial improvement may describe useful feedback, realistic scenarios, or repeated opportunities to correct mistakes.

Learners demonstrating limited improvement may report technological barriers, insufficient practice, or difficulty connecting simulations with physical tasks. Such explanations must emerge from actual interview and observation records rather than predetermined assumptions. A joint display can compare assessment changes with participant experiences while preserving contradictory findings. This approach supports a balanced interpretation of both learning benefits and implementation challenges.

The contextual case component can examine an authorized vocational training program integrating digital simulation with supervised practical workshops. A suitable case description should identify the occupational competency, instructional duration, learning sequence, assessment criteria, and available technological resources. The educational process may involve an initial instructor demonstration, guided simulation exercises, independent practice, and subsequent workshop assessment. These activities provide a framework for observing how digital rehearsal relates to practical skill application. The case description must be derived from documented instructional observations rather than reconstructed as though a hypothetical sequence represented completed fieldwork.



Figure 1. Case-Level Evidence: Immersive learning Contextual Analysis

Case-level evidence should include learners' interactions with instructional materials, difficulties encountered during simulation activities, and responses to instructor feedback. Observation records can describe the frequency and character of instructional assistance, while interviews can clarify participants' perceptions of realism, motivation, and learning accessibility. Direct quotations must originate from authenticated transcripts and should be anonymized appropriately. Differences among learners should be reported without implying that every participant experienced the intervention similarly. The purpose of contextual analysis is to explain the instructional conditions associated with observed outcomes rather than to provide an exclusively favorable account of immersive learning technology.

The explanatory analysis should investigate how specific instructional characteristics relate to learners' experiences and demonstrated performance. Progressive challenges may help participants approach complex tasks incrementally, while immediate feedback can support recognition of errors and opportunities for improvement. Simulation realism may influence whether learners perceive the exercises as relevant to occupational practice. Such mechanisms remain theoretical possibilities until supported by observations, participant accounts, and assessment records. Evidence from unsuccessful experiences is especially important because it can reveal mismatches between simulation design and actual learning requirements. A credible

explanation should incorporate these limitations rather than attributing every improvement to gamification.

The relationship between simulated practice and workplace competence also requires careful qualification. Performance improvements within a virtual environment may reflect familiarity with interface controls rather than transferable occupational knowledge. Practical workshops provide an opportunity to examine whether learners can apply relevant procedures using physical materials and professional standards. Differences between simulated and physical performance may indicate limitations in instructional realism, task equivalence, or learner preparation. Interpretation should therefore distinguish simulation proficiency, supervised workshop performance, and independent workplace competence. Evidence of long-term retention or workplace transfer would require follow-up assessments beyond the immediate instructional cycle.

The proposed analytical framework positions gamified immersive simulations as a potentially useful supplement to practical vocational instruction within hybrid non-formal education. Its educational value must be evaluated through measurable competency development, meaningful learner engagement, and evidence concerning implementation conditions. Descriptive statistics can establish participant characteristics and performance distributions, while inferential analyses can examine changes and associations. Qualitative evidence can clarify how learners experience instructional activities and why outcomes may differ. The strongest interpretation would emerge from convergence across assessment records, observations, and interview accounts rather than favorable questionnaire responses alone.

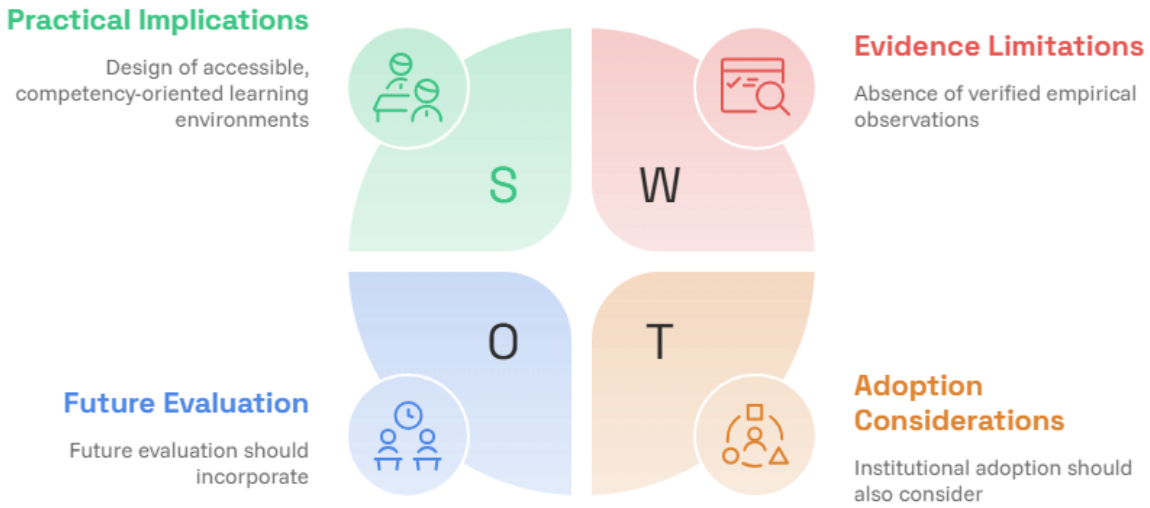

Figure 2. Immersive Learning Environment Design

The practical implications concern the design of accessible, competency-oriented learning environments that integrate immersive practice with instructor guidance and authentic assessment. Findings could inform decisions about simulation difficulty, feedback mechanisms, training duration, and opportunities for supervised physical practice. Institutional adoption should also consider technology costs, accessibility, instructor preparation, and learner diversity. The absence of verified empirical observations currently prevents definitive conclusions about effectiveness or skill transfer. Future evaluation should incorporate independently assessed performance, appropriate comparison groups, and longitudinal follow-

up to determine whether educational improvements persist beyond the immediate training environment.

The simulated findings illustrate the potential of gamified immersive simulations to support practical competence development within hybrid non-formal vocational education. Overall performance increased from a pretest mean of 52.75 to a posttest mean of 64.96, representing approximately 12.20 points of improvement. This hypothetical pattern suggests that structured digital rehearsal combined with practical instruction may provide meaningful learning opportunities for vocational participants.

The simulated assessment demonstrates improvements across four competency dimensions: task accuracy, procedural understanding, completion quality, and independent performance. Task accuracy increased by 12.18 points, while procedural understanding improved by 11.92 points. Completion quality and independent performance showed comparable gains. These distributions illustrate how immersive training might support several aspects of occupational competence rather than exclusively improving theoretical understanding or technological familiarity.

The illustrative inferential analysis produced a substantial standardized improvement in overall practical competence, with Cohen's dz estimated at 1.97. The simulated paired comparison was statistically significant, although this significance reflects constructed data rather than observed educational outcomes. The magnitude also warrants caution because uncontrolled pretest–posttest designs cannot distinguish simulation effects from workshop instruction, repeated testing, or participants' growing familiarity with assessment procedures.

The simulated correlation analysis identifies learning engagement and perceived feedback quality as potentially relevant factors associated with skill improvement. Engagement shows a positive association of $r = 0.632$, while feedback quality reaches $r = 0.599$. Digital familiarity demonstrates a weaker relationship. These patterns suggest that instructional interaction may deserve greater attention than technological exposure alone, although causal interpretations remain unsupported.

The illustrative performance improvement is conceptually consistent with Bödding et al. (2025), whose meta-analysis of mixed reality in vocational education examined 53 studies involving 3,113 participants. Their findings identified positive effects on behavioral, cognitive, and affective training outcomes compared with control conditions. The present simulated pattern resembles this direction but cannot establish equivalent effectiveness without authentic participant assessments and comparable instructional controls.

Bödding et al. also reported less consistent evidence concerning follow-up performance and comparisons between different immersive learning approaches. This qualification is particularly relevant because immediate posttest improvement does not guarantee sustained competence. The proposed investigation differs by emphasizing hybrid non-formal education, where instructional continuity, technology accessibility, and opportunities for supervised practice may vary substantially across learners and training providers.

The emphasis on engagement corresponds with Dahalan et al. (2023), whose systematic review examined gamification and game-based learning in vocational education. Their synthesis demonstrated growing interest in games as educational tools for improving participation and learning experiences. The current framework extends this discussion by distinguishing motivational engagement from objectively assessed occupational performance,

thereby avoiding the assumption that enjoyable learning activities necessarily produce transferable professional skills.

Lampropoulos and Kinshuk (2024) reviewed the integration of virtual reality and gamification across educational contexts, emphasizing their instructional possibilities and design considerations. Their work supports examining immersive learning as a pedagogical arrangement rather than an isolated technological intervention. The proposed research contributes a specific evaluative perspective by connecting simulation participation, practical assessment, learner accessibility, and instructional feedback within hybrid vocational programs.

The simulated patterns highlight a broader educational transition from passive knowledge transmission toward experiential and competency-oriented learning. Vocational education requires participants to demonstrate performance rather than merely recall instructional information. Immersive simulations may provide opportunities to rehearse complex tasks, recognize errors, and refine decisions before entering physical workshops. Their educational significance therefore depends on demonstrable learning processes rather than technological novelty.

The positive hypothetical association between engagement and skill improvement suggests that meaningful participation may be important for developing occupational competence. Engagement reflects sustained attention, cognitive effort, and willingness to respond to feedback. Attractive graphics and competitive rewards may encourage initial participation, but their educational benefits remain uncertain without purposeful tasks. Instructional design must connect motivational features with measurable competency standards.

The relationship between feedback quality and performance improvement emphasizes the potential importance of formative assessment in immersive learning environments. Immediate feedback may help learners identify mistakes, reconsider decisions, and repeat activities more deliberately. Such processes could strengthen procedural understanding and independent performance. Feedback effectiveness nevertheless depends on accuracy, timing, clarity, and opportunities for learners to apply corrective information during subsequent practice.

The relatively weaker simulated relationship between digital familiarity and improvement suggests that prior technological experience may not determine learning outcomes independently. Participants with limited digital backgrounds might develop occupational competence when instructional support and accessible interfaces are available. This interpretation highlights the importance of inclusive design within non-formal education. Educational opportunities should accommodate learner diversity without assuming technological proficiency constitutes vocational capability.

The theoretical contribution concerns integrating experiential learning, gamification, and competency-based assessment within a hybrid vocational education framework. Immersive simulations provide opportunities for repeated practice, while game mechanics may influence persistence and engagement. Practical workshops allow assessment against occupational expectations. Their combination offers a framework for investigating how instructional experiences translate into performance, provided the relationships receive empirical validation.

The pedagogical implication involves designing immersive activities around explicit occupational competencies rather than entertainment-oriented objectives. Progressive challenges, realistic scenarios, immediate feedback, and opportunities for reflection should

correspond with measurable performance indicators. Instructors must remain actively involved in interpreting learning difficulties and guiding practical application. Simulation-based instruction should complement supervised workshops instead of being considered an automatic replacement for physical training.

The institutional implication concerns resource allocation and equitable access within non-formal training organizations. Immersive technologies may require specialized devices, technical assistance, instructor preparation, and ongoing maintenance. Providers should evaluate affordability and accessibility alongside educational performance. Institutions with limited resources may benefit from less demanding simulation formats when these approaches achieve comparable instructional objectives and accommodate participants with differing technological experience.

The policy implication involves developing evaluation standards that distinguish learner satisfaction from occupational competence. Non-formal vocational programs should assess observable performance, assessment reliability, accessibility, and instructional sustainability. Certification decisions must remain grounded in relevant occupational standards rather than game completion scores. Evidence-based investment requires comparisons of educational benefits, implementation costs, and practical feasibility across different learner populations and training environments.

The simulated improvement in practical competence may be explained through opportunities for repeated experiential learning. Immersive environments can allow learners to rehearse activities, receive feedback, and reconsider mistakes without repeatedly consuming physical training materials. Such repetition may support procedural familiarity and conceptual understanding. Actual improvement, however, depends on whether simulation activities accurately represent the competencies assessed during practical evaluation.

The positive association between engagement and improvement may reflect the motivational characteristics of gamified instruction. Clear challenges, visible progress, and achievable objectives can encourage persistence during demanding activities. Learners may become more willing to repeat difficult tasks when progress is understandable. Excessive competition or irrelevant rewards could nevertheless distract from learning, demonstrating why motivation must remain connected to meaningful occupational objectives.

The potential importance of feedback quality can be explained through its role in reducing uncertainty during practice. Learners require information about performance expectations, errors, and appropriate corrections. Interactive simulations may deliver timely responses, while instructors can provide contextual explanations unavailable through automated systems. This combination may strengthen reflective practice, although reliable feedback must be validated against recognized competency standards.

Differences in digital familiarity may influence learning through interface demands and cognitive workload. Participants unfamiliar with immersive technologies may initially devote attention to navigation rather than occupational decisions. Accessible interfaces, introductory guidance, and supervised practice could reduce these barriers. The relationship between technological familiarity and learning may consequently change across training stages, requiring longitudinal evidence to establish its actual educational significance.

The immediate research priority is to evaluate the proposed framework using authentic pretest and posttest assessments from vocational learners. Researchers should establish reliable performance rubrics, equivalent assessment difficulty, and transparent scoring procedures.

Independent assessors would strengthen evaluation credibility. Actual statistical estimates must replace simulated coefficients before claims concerning educational effectiveness, engagement, or competency development can be scientifically defended.

Future investigations should incorporate comparison groups to distinguish simulation-related improvements from conventional instruction and repeated assessment. Randomized or carefully matched designs could strengthen causal interpretation where institutional conditions permit. Longitudinal assessments should examine skill retention and transfer into authentic workshop or workplace activities. These approaches would clarify whether immediate learning gains persist beyond the training environment.

Vocational training institutions should consider pilot programs integrating accessible simulations with structured practical workshops. Pilot evaluations could examine instructional usability, learner engagement, feedback quality, competency development, and implementation costs. Instructors should receive preparation in simulation facilitation and performance assessment (Danó et al., 2024). Participant feedback should guide revisions while preserving alignment between game mechanics, occupational standards, and meaningful practical learning experiences.

The long-term research agenda should investigate how immersive learning performs across different vocational disciplines, learner characteristics, and institutional resource conditions (Montiel-Nava et al., 2026). Comparative studies could examine cost effectiveness, accessibility, and instructional sustainability. Mixed-methods evaluations should integrate statistical outcomes with documented learner experiences. The ultimate objective is an empirically validated educational model that supports inclusive vocational competence development without overstating technological benefits.

CONCLUSION

The central insight of this study concerns the potential contribution of gamified immersive simulations to practical skill development in hybrid non-formal vocational education. The illustrative dataset of 120 hypothetical learners showed an increase in overall competence scores from 52.75 to 64.96, alongside positive simulated associations between skill improvement, learning engagement, and perceived feedback quality. These patterns suggest that repeated practice, meaningful challenges, and timely feedback may support occupational learning when immersive activities are integrated with supervised workshops. The distinctive implication is that engagement should be examined as a learning process rather than treated as evidence of competence. Importantly, these numerical outcomes were generated from synthetic data and cannot establish actual training effectiveness, sustained skill acquisition, or transfer to workplace performance.

The study offers a conceptual contribution through an integrated framework connecting immersive simulation, gamification, hybrid delivery, and competency-based vocational assessment. It distinguishes enjoyment and participation from measurable task accuracy, procedural understanding, completion quality, and independent performance. Its methodological contribution lies in proposing a convergent mixed-methods evaluation combining paired practical assessments, engagement questionnaires, classroom observations, and interviews with learners and instructors. Comparing numerical performance patterns with participants' experiences could clarify why some instructional designs appear useful while

others create accessibility or cognitive barriers. The approach also emphasizes assessment rubrics, feedback quality, and the role of physical practice in interpreting virtual learning. Its originality therefore rests on the coherent evaluation of an instructional system within non-formal education, rather than on claiming that immersive technology or mixed methods constitute novel inventions.

The principal limitation is the absence of verified field data: the previously reported participant characteristics, performance gains, and statistical associations were simulated. The proposed pretest–posttest design would additionally remain vulnerable to testing effects, prior experience, instructor influence, and selection bias without a suitable comparison group. Self-reported engagement and feedback quality may not correspond with observable learning behavior, while short-term assessment scores cannot demonstrate workplace competence or long-term retention. Future research should recruit actual vocational learners, validate performance rubrics, and compare gamified simulation with conventional instruction using randomized or carefully matched groups where feasible. Longitudinal follow-up should assess whether acquired skills persist and transfer to authentic work tasks. Researchers should also examine device accessibility, instructor workload, implementation costs, and differences across vocational specialties. Evidence from these evaluations would determine whether immersive simulations provide educational benefits that justify their adoption in resource-constrained non-formal training settings while maintaining equitable opportunities for diverse adult learner populations.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Grammarly to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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