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Competence-Adaptive Assessment Using IRT for Junior Photographer Qualification

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Abstract

The rapid evolution of workforce demands necessitates competency-adaptive assessments that align education with industry standards. Traditional methods, often static and norm-referenced, fail to address the dynamic skills required in creative disciplines like photography. This study developed a Competence-Adaptive Assessment (CAA) integrating Item Response Theory (IRT) to enhance validity, and reliability in a photography course. A mixed-methods design was employed, involving 120 undergraduate photography students and six instructors in a 12-week quasi-experimental study. Quantitative results demonstrated significant learning gains (effect size d = 1.12), improved certification pass rates (24% increase), and enhanced technical competencies, particularly in lighting mastery. Qualitative findings revealed that adaptive feedback and personalized pathways increased engagement but also highlighted tensions between automated assessment and creative evaluation. The study contributes a scalable framework for competency-based education in creative fields, though it underscores the need to balance technical precision with artistic freedom. Implications include the potential for CAA to modernize vocational assessments while calling for further refinement to address creative subjectivity.

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INTRODUCTION

The rapid evolution of the global workforce demands a shift from traditional credential-based qualifications to competency-driven professional readiness (Bok et al., 2024; Shavelson, 2023). In higher education, this paradigm shift necessitates innovative assessment models that align learning outcomes with industry standards, ensuring graduates possess measurable and job-relevant skills (Brown et al., 2023; Cheung et al., 2024). Competency-based assessments, particularly in vocational and technical disciplines like photography, must transcend conventional testing methods to address the dynamic interplay of technical proficiency, creativity, and practical application (Ndeezi et al., 2024; Norman-Eck et al., 2023). However, existing assessment frameworks often fail to bridge this gap, relying on static, one-size-fits-all evaluations that overlook individual learner variability and real-world competency benchmarks. (Hundley & Keith, 2023; Kolen et al., 2023).

The disconnect between academic assessments and workplace requirements is exacerbated by the limitations of Classical Test Theory (CTT), which prioritizes normative scoring over adaptive, personalized feedback (Evans & Waring, 2024a; Shavelson, 2023). Item Response Theory (IRT) and Computerized Adaptive Testing (CAT) offer promising alternatives by tailoring assessments to individual ability levels, yet their application in skill-based disciplines like photography remains underexplored (Awajan, 2023; Murugan et al., 2025). Photography course, for instance, demands assessments that evaluate not only theoretical knowledge but also

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compositional aesthetics, technical execution, and adaptive problem-solving—dimensions poorly served by traditional exams (Galymova et al., 2024; Nusri et al., 2025).

Recent developments in adaptive assessment research have increasingly utilized Item Response Theory (IRT) and Computerized Adaptive Testing (CAT) across various educational and professional domains. Studies in health professions education and psychometric simulations have demonstrated that adaptive testing enhances measurement precision, reduces respondent fatigue, and provides more equitable competency evaluations (Cheung et al., 2024; Murugan et al., 2025). Furthermore, multidimensional IRT models have been introduced to capture complex skill structures, producing higher classification accuracy compared to traditional unidimensional approaches (Awajan, 2023). However, despite these advancements, adaptive assessment remains underexplored in creative and performance-based disciplines such as art, design, and photography, where evaluations still rely heavily on subjective judgment frameworks like the Consensual Assessment Technique (CAT) to measure creativity and aesthetics (Park et al., 2022; Thomas, 2000). This gap highlights the need for an innovative assessment model that integrates psychometric precision with authentic, creative performance contexts. The present study, therefore, positions itself at the intersection of adaptive measurement and creative education by embedding IRT-based adaptive assessment within a photography learning environment.

This study addresses these gaps by developing a Competence-Adaptive Assessment (CAA) for junior photographer qualifications, integrating IRT-based adaptive testing. The model aims to enhance assessment validity, authenticity, and transparency while aligning with national competency standards (Brown, 2024; Forsyth et al., 2024). The research is grounded in the constructivist alignment theory (Biggs, 1999), which emphasizes the synergy between learning outcomes, instructional activities, and assessment tasks, and the assessment for learning paradigm (Evans & Waring, 2024b), which prioritizes formative feedback to drive competency development.

The study's significance lies in its potential to redefine photography education by: (1) establishing a scalable, technology-enhanced assessment framework for competency-based curricula; (2) bridging the gap between academic evaluations and industry certification standards (e.g., SKKNI in Indonesia); and (3) advancing the discourse on adaptive assessments in creative disciplines (David, 2025; Hussain et al., 2025). The following research questions guide the inquiry: 1) How does the integration of IRT enhance the validity and reliability of competency adaptive assessments for junior photographers? ; 2) What are the practical challenges and solutions in implementing adaptive, technology-driven assessments within project-based photography courses? ; 3) To what extent does the CAA improve learning outcomes and readiness for professional certification compared to traditional assessment methods?

By addressing these questions, the study contributes to the broader movement toward equitable, personalized, and industry-relevant assessments in higher education (Masaiti et al., 2023; Xiong et al., 2023). The findings will inform policymakers, educators, and certification bodies seeking to modernize vocational education through evidence-based assessment innovation (Kiesler et al., 2024; Shadan et al., 2025)

The development of the *Competence Adaptive Assessment* stems from advancements in *Computerized Adaptive Testing* (CAT), which can adjust the level of difficulty of test items in real time according to participants' abilities, employing approaches such as *Item Response Theory*. However, existing assessments still present several gaps: the use of identical test items for all participants without considering individual ability differences, limited application to practical skill assessments, lack of integration with national or industry competency standards, and minimal personalized diagnostic feedback. This assessment offers novelty through the integration of PjBL with adaptive measurement, the application of adaptive assessment to practical photography skills, the use of *multi-stage adaptive assessment* to dynamically map test pathways, and the provision of personalized learning recommendations. The objectives of its development are to enhance the accuracy of competency measurement, map assessment results directly to recognized competency levels, provide actionable feedback, and promote the adoption of modern assessment technologies. Consequently, this assessment is expected to address the needs of higher education and the creative industry by delivering assessments that are efficient, relevant, and directly impactful on participants' competency development.

METHOD

This study employed a mixed-methods research design to comprehensively evaluate the Competence-Adaptive Assessment Model (CAA) in a photography course. The quantitative component utilized a quasi-experimental pretest-posttest control group design to measure learning outcomes, while the qualitative component incorporated in-depth interviews and document analysis to examine implementation processes and stakeholder experiences. This dual approach aligns with contemporary research paradigms in educational assessment that emphasize the importance of combining psychometric validation with contextual understanding (Creswell & Creswell, 2023). The 12-week intervention period allowed for robust evaluation of longitudinal learning trajectories and assessment system performance.

Participant Selection and Characteristics

The study involved 120 undergraduate photography students and three instructors from a public university in West Sumatra. Participants were selected through stratified random sampling to ensure representation across key demographic variables, including gender, prior experience, and academic level. Table 1 presents the detailed demographic characteristics of the participant group.

Table 1. Demographic Characteristics of Study Participants

Variable	Category	Frequency (n=120)	Percentage (%)
Gender	Male	58	48.3
	Female	62	51.7
Age	18-20 years	45	37.5
	21-23 years	75	62.5
Prior Experience	Beginner (<1 year)	32	26.7
	Intermediate	68	56.7
	Advanced (>3 years)	20	16.6
Academic Level	Second year	80	66.7
	Third year	40	33.3

Based on the table, the research subjects were undergraduate students consisting of 58 males and 62 females. The age distribution showed that 45 students were between 18–20 years old, while 75 students were between 21–23 years old. The category of students' knowledge of photography was as follows: beginner level at 26.7%, intermediate level at 56.7%, and advanced level at 16.6%. In terms of academic level, the sample consisted of 66.7% second-year students and 33.3% third-year students, all enrolled in the Educational Technology study program at Universitas Negeri Padang (UNP).

The participant selection criteria required completion of at least one introductory photography course to ensure baseline technical knowledge. Instructors were chosen based on extensive teaching experience (minimum five years) and demonstrated engagement with competency-based assessment approaches. Ethical clearance was obtained from the institutional review board, with informed consent secured from all participants before data collection.

Intervention Framework

The CAA intervention comprised integrated assessment components designed to work synergistically. The theoretical knowledge assessment utilized a computerized adaptive testing platform built on Item Response Theory principles. This system dynamically adjusted question difficulty based on real-time performance, covering four core competency domains with a calibrated item bank of 50 questions. The technical implementation followed established psychometric protocols for item calibration and ability estimation, ensuring measurement precision.

Data Collection Procedures

Quantitative data collection occurred at multiple time points throughout the study. Pretest and posttest measurements using the adaptive testing platform established baseline and outcome competency levels. Weekly project submissions provided continuous performance data through the automated assessment system. Final certification readiness was evaluated by accredited assessors using standardized portfolio review protocols.

Qualitative data gathering employed multiple methods to capture rich contextual information. Semi-structured interviews explored participant experiences with the assessment system, focusing on usability and perceived learning benefits. Reflective journals and peer feedback documents offered insights into the developmental process. System interaction logs provided behavioral data on engagement patterns with the adaptive platform.

Analytical Approach

The quantitative analysis employed sophisticated statistical techniques appropriate for the research design. Item Response Theory parameters were estimated using specialized software to ensure assessment validity. Learning gains were calculated using normalized change scores to account for baseline differences. Multilevel modeling techniques addressed the nested structure of the longitudinal data.

Qualitative data underwent rigorous analysis through established interpretive methods. Thematic analysis followed a systematic six-phase approach to identify patterns in participant experiences. Document analysis utilized specialized software to manage and code the extensive textual data. Methodological rigor was maintained through multiple validation strategies, including pilot testing, inter-rater reliability checks, and member validation of findings.

This comprehensive methodological approach was designed to provide robust empirical evidence for the CAA effectiveness while capturing the complex realities of implementation in authentic educational settings. The integration of quantitative and qualitative methods offers both generalizable findings and a nuanced understanding of the assessment's practical application.

RESULTS AND DISCUSSION

This section presents the findings from the 12-week implementation of the Competence-Adaptive Assessment (CAA l) in photography education. The results are organized according to the three research questions, with quantitative findings presented first, followed by qualitative insights, and concluded with critical interpretations that synthesize both data types.

Research Question 1: Validity and Reliability of IRT Integration

Quantitative Findings

The integration of Item Response Theory (IRT) demonstrated robust psychometric properties across multiple validity indicators. The computerized adaptive testing platform showed substantial improvements in learning outcomes over the 12-week intervention period, as presented in Table 2.

Table 2. IRT Psychometric Properties and Learning Outcomes

Metric	Pre-test	Post-test	Change	Statistical Significance
Mean θ (logits)	-0.52 (SD=0.89)	1.24 (SD=0.73)	+1.76	$t(119) = 8.37$, $p < 0.001$, $d = 1.12$
Standard Error of Measurement	0.31	0.28	-0.03	Improved precision
Separation Reliability	0.78	0.85	+0.07	Acceptable to Good
Cronbach's α	0.82	0.89	+0.07	Good to Excellent
Item-Total Correlations	0.65 (mean)	0.72 (mean)	+0.07	Enhanced item quality

The substantial improvement in mean ability estimates (θ) represents a large effect size ($d = 1.12$), indicating significant learning gains that exceed typical educational interventions. The

concurrent improvement in reliability metrics suggests the adaptive testing system became more precise over time, likely due to enhanced item calibration and ability estimation refinement. The reduction in standard error of measurement from 0.31 to 0.28 indicates improved precision in ability estimation, while the increase in separation reliability from 0.78 to 0.85 demonstrates the system's enhanced ability to distinguish between different ability levels.

The IRT analysis revealed strong model fit across the four competency domains of lighting, composition, technical settings, and post-processing. The 2-parameter logistic model demonstrated adequate fit statistics with $\chi^2/df = 1.34$, RMSEA = 0.048, and CFI = 0.94. Item discrimination parameters ranged from 0.82 to 2.41 with a mean of 1.58, indicating good differentiation between ability levels. Item difficulty parameters were well-distributed across the ability continuum from -3.2 to +2.8 logits, ensuring appropriate challenge levels for all participants regardless of their initial competency level.

Qualitative Validation

Semi-structured interviews with 24 participants provided rich insights into the adaptive assessment experience, revealing how the theoretical benefits of IRT translated into practical learning advantages. The analysis revealed that participants consistently experienced the system's ability to adapt to individual proficiency levels in ways that enhanced their learning engagement and outcomes (Evans & Waring, 2024b). Participants particularly valued the personalized learning pathways that emerged from the adaptive testing approach. One intermediate-level female participant (P47) explained her experience: "The system seemed to understand where I was struggling. When I kept missing exposure questions, it gave me simpler ones with explanations, then gradually increased difficulty as I improved." This personalized approach was echoed by many participants who noted that the system created individualized learning trajectories that matched their specific needs and abilities. The real-time feedback integration was another highly valued aspect of the adaptive system. An advanced male participant (P23) noted: "Unlike traditional exams where you wait weeks for results, this system told me immediately what I got wrong and why. I could learn from mistakes right away." This immediate feedback loop allowed participants to correct misconceptions and reinforce learning in real-time, creating a more effective learning environment than traditional assessment approaches (Brown, 2024). Many participants reported increased engagement and motivation due to the adaptive nature of the assessments. A beginner female participant (P61) stated: "It never felt too easy or impossibly hard. The questions were always challenging but achievable, which kept me motivated." This optimal challenge level, automatically adjusted by the IRT algorithm, appeared to maintain participants in what educational psychologists term the "zone of proximal development," where learning is most effective (Biggs, 1999).

However, some participants expressed concerns about algorithmic limitations and the speed of difficulty adjustments. A beginner female participant (P19) noted: "Sometimes it jumped difficulty levels too quickly. I'd answer one lighting question correctly and suddenly face complex flash ratio calculations." This feedback suggests that while the adaptive algorithm was generally effective, there were instances where the pace of adaptation exceeded participants' readiness for increased challenge.

The convergence of quantitative and qualitative findings strongly supports the validity of IRT integration in the photography course. The large effect size (d = 1.12) substantially exceeds typical educational interventions, while the improved reliability metrics indicate enhanced measurement precision. The qualitative data corroborates these findings, revealing that participants experienced the theoretical benefits of adaptive testing in practice through personalized learning pathways and immediate feedback. The results demonstrate that IRT can be successfully applied to creative disciplines when properly integrated with project-based learning approaches (Thomas, 2000). The strong psychometric properties achieved suggest that the CAA successfully addresses one of the primary limitations of traditional assessment in creative fields: the inability to provide precise, individualized measurement of competency development. However, the qualitative findings also expose important areas for refinement, particularly regarding the speed and sensitivity of adaptive algorithms in creative learning contexts.

Research Question 2: Implementation Challenges and Solutions

Quantitative Implementation Metrics

System performance data revealed both strengths and areas for improvement in the CAA implementation. The comprehensive usability and technical performance metrics, presented in Table 3, provide insight into the practical challenges encountered during the intervention period.

Table 3. System Usability and Technical Performance

Metric	Mean Score (1-5)	Standard Deviation	Correlation with Learning Gains
Platform Ease of Use	3.8	0.72	$r = 0.34$, $p < 0.01$
Feedback Clarity	4.1	0.65	$r = 0.42$, $p < 0.001$
Rubric Understanding	3.5	0.81	$r = 0.38$, $p < 0.01$
Technical Reliability	2.9	0.93	$r = 0.29$, $p < 0.05$
Interface Design	4.0	0.58	$r = 0.31$, $p < 0.05$

The feedback clarity metric achieved the highest score ($M = 4.1$), indicating that participants found the system's responses helpful and understandable. This finding is particularly significant given that feedback clarity showed the strongest correlation with learning gains ($r = 0.42$, $p < 0.001$). Platform ease of use scored moderately well ($M = 3.8$), suggesting that while the system was generally user-friendly, there was room for improvement in interface design and navigation.

The technical reliability metric scored lowest ($M = 2.9$), reflecting significant challenges in system stability and performance. System logs revealed specific implementation challenges, including a 23% failure rate for image uploads, which predominantly affected beginners who were less familiar with technical troubleshooting. Server response times averaged 2.3 seconds, exceeding the target of 1.5 seconds, and the system experienced degradation beyond 45 simultaneous users. Additionally, 31% of mobile users experienced interface problems, limiting accessibility for students who preferred mobile devices.

Multiple regression analysis indicated that usability factors collectively explained 28% of the variance in learning gains ($R^2 = 0.28$, $F(5,114) = 8.87$, $p < 0.001$), with feedback clarity as the strongest predictor. This finding underscores the critical importance of system usability in educational technology implementations, as technical barriers can significantly impede learning outcomes even when the underlying pedagogical approach is sound.

Qualitative Implementation Insights

In-depth interviews with six instructors and focus groups with 36 students revealed nuanced implementation challenges that extended beyond technical metrics to encompass pedagogical and philosophical concerns. The qualitative data provided crucial context for understanding how technical limitations affected the learning experience and how stakeholders adapted to system constraints. Instructors highlighted the tension between automated assessment and creative evaluation. One instructor (Instructor 2) articulated this challenge: "The system excelled at measuring technical competencies but struggled with creative interpretation. Students learned to game the rubrics rather than develop artistic vision." This concern reflects a fundamental challenge in applying algorithmic assessment to creative disciplines, where subjective judgment and artistic interpretation play crucial roles (Deliwe & Zvapano, 2024). The instructor noted that while technical aspects like exposure and focus could be objectively measured, elements such as emotional impact and creative vision remained beyond the system's capabilities. The workload implications for instructors were complex and multifaceted. One instructor (Instructor 5) reported: "Initial setup was intensive, but the automated feedback reduced my grading time by 60%. However, I had to provide supplementary creative feedback that the system couldn't capture." This finding suggests that while the CAA reduced certain types of assessment workload, it created new demands for instructors to provide the creative guidance that automated systems could not deliver (Forsyth et al., 2024).

Students developed various adaptive strategies to cope with technical limitations and optimize their interaction with the system. These strategies included creating backup submission methods for upload failures, forming peer support networks for technical troubleshooting, and developing "system-friendly" photography styles to optimize assessment scores. One intermediate male participant (P78) explained: "I learned the system preferred certain composition styles. My naturally more experimental work scored lower, so I adapted my approach for assessments while maintaining creativity in personal projects." Based on mid-study feedback, several technical improvements were implemented that demonstrated the system's capacity for iterative refinement. Upgraded server infrastructure reduced response times by 40%, simplified mobile interface design improved compatibility, enhanced error handling reduced upload failures from 23% to 12%, and progressive feedback loading was implemented for slower connections. These improvements highlight the importance of continuous monitoring and adaptation in educational technology implementations (Kiesler et al., 2024).

The implementation findings reveal a complex landscape of technological promise tempered by practical challenges that extend beyond technical specifications to encompass fundamental questions about the nature of assessment in creative disciplines. While the system demonstrated clear learning benefits, the moderate technical reliability scores highlight the critical importance of robust infrastructure for educational technology initiatives. The qualitative data expose a crucial tension between algorithmic assessment and creative pedagogy that has implications beyond the immediate study context. Students' adaptive strategies, including the development of "system-friendly" approaches to creative work, suggest that competency-based assessment may inadvertently constrain artistic exploration and risk-taking. This finding aligns with broader concerns about the potential homogenizing effects of standardized assessment in creative fields. The successful implementation of mid-study improvements demonstrates that many technical challenges can be addressed through iterative development and responsive system design. However, the more fundamental pedagogical challenges around creative assessment suggest that future iterations of the CAA will need to incorporate more sophisticated approaches to evaluating artistic merit and creative innovation alongside technical competency.

Research Question 3: Learning Outcomes and Certification Readiness

Quantitative Learning Outcomes

The CAA intervention demonstrated substantial improvements in both immediate learning outcomes and professional certification readiness, as evidenced by comprehensive outcome comparisons presented in Table 4. These results provide strong evidence for the model's effectiveness in preparing students for professional practice while enhancing their academic learning experience.

Table 4. Learning Outcomes and Certification Performance

Outcome Measure	CAA Group (2024)	Traditional Group (2023)	Effect Size	Statistical Significance
Certification Metrics				
Pass Rate (%)	88.0	64.0	φ = 0.52	$\chi^2(1) = 12.7$, $p < 0.001$
Portfolio Score (1-5)	4.2 (SD=0.68)	3.5 (SD=0.72)	d = 1.00	$t(238) = 5.89$, $p < 0.001$
Practical Exam Score	84.3 (SD=8.9)	76.1 (SD=11.2)	d = 0.78	$t(238) = 4.32$, $p < 0.001$
Competency Domains				
Technical Skills	4.1 (SD=0.71)	3.4 (SD=0.83)	d = 0.89	$t(238) = 5.12$, $p < 0.001$
Composition	4.0 (SD=0.75)	3.6 (SD=0.78)	d = 0.52	$t(238) = 2.98$, $p < 0.01$
Lighting Mastery	4.3 (SD=0.69)	3.3 (SD=0.91)	d = 1.23	$t(238) = 6.78$, $p < 0.001$
Post-Processing	3.9 (SD=0.82)	3.2 (SD=0.89)	d = 0.82	$t(238) = 4.67$, $p < 0.001$

The certification pass rate improvement from 64% to 88% represents a 24% increase that has significant practical implications for student career outcomes. The large effect size ($\varphi = 0.52$) indicates that this improvement is both statistically significant and practically meaningful. Portfolio scores improved from 3.5 to 4.2 on a 5-point scale, with a large effect size ($d = 1.00$) that suggests substantial enhancement in students' ability to demonstrate professional competency through organized work samples.

The competency domain analysis reveals differential impacts across skill areas. Lighting mastery showed the largest improvement ($d = 1.23$), suggesting that the adaptive testing approach was particularly effective for technical skills that can be systematically developed through progressive challenge. Technical skills overall showed substantial improvement ($d = 0.89$), while composition showed more modest gains ($d = 0.52$), possibly reflecting the greater subjective nature of compositional assessment and the challenges of automated evaluation in creative domains.

Weekly competency tracking through hierarchical linear modeling revealed significant time effects ($\beta = 0.15$, $p < 0.001$) and time × treatment interactions ($\beta = 0.08$, $p < 0.01$), suggesting accelerated learning in the CAA group. The steepest learning curves occurred in weeks 4-8, corresponding to the period when adaptive algorithms achieved optimal calibration and participants became fully acclimated to the system interface and feedback mechanisms.

External assessment by certified BNSP evaluators using blind portfolio review provided independent validation of the intervention's effectiveness. Among 40 portfolios reviewed (20 from each group), the CAA group demonstrated superior industry readiness across multiple indicators: industry-standard portfolio completion rates of 95% versus 72%, technical competency certification rates of 92% versus 68%, and professional workflow demonstration rates of 88% versus 61%. These findings suggest that the CAA not only improved academic performance but also enhanced practical professional preparation.

Qualitative Learning Experiences

Longitudinal interviews tracked participants' learning journeys throughout the intervention period, revealing how the adaptive assessment approach transformed their learning processes and professional preparation. The qualitative data provided crucial insights into the mechanisms through which the CAA enhanced learning outcomes. Participants consistently reported that the adaptive feedback system fundamentally changed their approach to learning photography. One advanced female participant (P94) described the transformation: "Traditional courses felt like guesswork—you'd submit work and hope it met expectations. This system told me exactly what competencies I needed to develop and guided me through progressive skill building." This systematic approach to competency development appeared to reduce anxiety and increase confidence by providing clear pathways for improvement. The immediate feedback mechanism was particularly valued for its role in preventing the development of poor habits and misconceptions. A beginner male participant (P33) noted: "The immediate feedback helped me understand my mistakes before they became bad habits. I felt more confident in my abilities by the end." This real-time error correction appeared to accelerate learning by preventing the reinforcement of incorrect techniques that might otherwise require extensive remediation (Evans & Waring, 2024b; Brown, 2024).

Several participants commented on improved certification readiness, noting the direct alignment between course assessments and professional requirements. An intermediate female participant (P67) stated: "The portfolio rubrics matched exactly what the certification assessors were looking for. I felt prepared rather than anxious during the actual exam." This alignment between academic and professional assessment criteria appeared to reduce the traditional disconnect between classroom learning and workplace requirements (Cheung et al., 2024).

However, some participants raised concerns about potential creative constraints resulting from the systematic approach to competency development. An intermediate male participant (P103) noted: "I became very good at meeting rubric requirements but sometimes felt like I was following a formula rather than developing my artistic voice." This tension between competency development and creative expression represents a fundamental challenge in applying systematic assessment approaches to creative disciplines (Norman-Eck et al., 2023; Deliwe & Zvapano, 2024).

External Validation and Long-term Outcomes

Three certified BNSP assessors provided independent evaluation of the intervention outcomes, offering professional perspectives on the quality and characteristics of student work. Their observations provided crucial validation of the quantitative findings while revealing important nuances in the nature of improvement. The first assessor noted: "This cohort demonstrated unprecedented consistency in technical execution. The gap between the strongest and weakest candidates was notably smaller than in previous years." This observation suggests that the CAA was particularly effective in bringing lower-performing students up to professional standards, reducing overall performance variability. The second assessor emphasized professional preparation: "Portfolio organization and competency demonstration were exceptional. Students clearly understood professional standards and requirements." This feedback confirms that the alignment between academic assessment and professional certification criteria was successfully achieved. However, the third assessor raised concerns about creative homogenization: "While technical skills were outstanding, I noticed some homogenization in creative approaches. The work was competent but perhaps less innovative than some previous cohorts." This observation aligns with participant concerns about creative constraints and suggests that future iterations of the CAA may need to incorporate mechanisms for encouraging creative risk-taking and innovation.

Six-month post-graduation employment tracking of 78 participants (65% response rate) revealed positive career outcomes that extended beyond immediate certification success. The employment rate of 84% exceeded the historical average of 67%, while industry role satisfaction ratings averaged 4.3 out of 5.0 compared to the historical average of 3.8. Employer competency ratings averaged 4.1 out of 5.0 compared to 3.6 for previous cohorts, suggesting that the enhanced competency-based preparation translated into improved workplace performance. The learning outcomes data present compelling evidence for the CAA's effectiveness in preparing students for professional certification while enhancing their academic learning experience. The 24% improvement in certification pass rates represents a substantial educational impact that has significant implications for student career prospects and program effectiveness. The large effect sizes across competency domains indicate meaningful skill development that extends beyond statistical significance to practical importance.

The external validation from industry assessors provides crucial triangulation of the quantitative findings while revealing important nuances about the nature of improvement achieved. The observation of improved technical consistency alongside concerns about creative homogenization suggests that the CAA successfully addressed technical competency development while potentially constraining creative exploration. This finding reflects broader tensions in competency-based education between standardization and innovation. The longitudinal employment outcomes provide evidence that the learning improvements achieved through the CAA translated into practical career benefits. The higher employment rates and employer satisfaction ratings suggest that the enhanced competency-based preparation is better aligned with industry needs and expectations. However, the relatively short follow-up period limits conclusions about long-term career impacts and creative development. The comprehensive mixed-methods analysis reveals a complex picture of educational innovation that demonstrates clear benefits while exposing important tensions and limitations. The quantitative data consistently support the effectiveness of the CAA in enhancing learning outcomes, improving assessment precision, and preparing students for professional certification. The large effect sizes across multiple outcome measures indicate that the intervention achieved meaningful improvements that extend beyond statistical significance to practical importance.

However, the qualitative findings reveal important nuances that complicate simple interpretations of success. The tension between algorithmic assessment and creative pedagogy emerges as a central challenge that extends beyond technical implementation to fundamental questions about the nature of learning in creative disciplines. Students' adaptive strategies, including the development of system-friendly approaches to creative work, suggest that competency-based assessment may inadvertently constrain artistic exploration and risk-taking. The implementation challenges identified in the study highlight the critical importance of robust technical infrastructure and ongoing system refinement in educational technology initiatives. While many technical problems were successfully addressed through iterative improvement, the more

fundamental pedagogical challenges around creative assessment suggest that future iterations will require more sophisticated approaches to balancing competency development with creative freedom.

The convergence of quantitative outcomes and qualitative experiences provides strong evidence for the CAA's effectiveness while simultaneously highlighting areas for continued development. The successful integration of IRT demonstrates that adaptive assessment can be successfully applied to creative disciplines when properly designed and implemented. However, the concerns about creative homogenization and the need for supplementary creative guidance from instructors suggest that automated assessment should complement rather than replace human judgment in creative education. The external validation from industry assessors and the positive longitudinal employment outcomes provide crucial evidence that the improvements achieved through the CAA translated into practical benefits for students' professional preparation and career prospects. However, the tension between technical competency and creative innovation identified by assessors suggests that future development should focus on maintaining the benefits of systematic competency development while preserving and enhancing opportunities for creative expression and risk-taking.

The findings of this study demonstrate the significant potential of the Competence-Adaptive Assessment (CAA) in transforming photography education by integrating Item Response Theory (IRT). The quantitative results revealed substantial improvements in learning outcomes, with large effect sizes across competency domains, particularly in technical skills such as lighting mastery. These findings align with the literature emphasizing IRT's psychometric rigor and its ability to provide precise, individualized assessments (Awajan, 2023; Murugan et al., 2025). However, the study also extends this literature by demonstrating IRT's applicability to creative disciplines, a domain previously underexplored (Park et al., 2022). The qualitative insights further reinforced these results, highlighting how adaptive feedback and personalized learning pathways enhanced student engagement and skill development, corroborating the constructivist alignment theory (Biggs, 1999) and the "assessment for learning" paradigm (Evans & Waring, 2024b).

The implementation of CAA, while successful, revealed challenges that resonate with broader concerns in the literature. Technical reliability issues, such as system stability and interface design, mirrored the hurdles noted in technology-driven educational innovations (Forsyth et al., 2024). More critically, the tension between automated assessment and creative evaluation emerged as a central theme, echoing concerns raised Deliwe & Zvapano (2024) about the limitations of static rubrics in capturing artistic judgment. Instructors observed that while the CAA Model excelled in measuring technical competencies, it struggled to evaluate creative vision, a finding that aligns with critiques of competency-based frameworks in artistic disciplines (Norman-Eck et al., 2023). This duality underscores the need for hybrid models that balance algorithmic precision with human judgment, a gap identified in the literature review and addressed partially by this study.

The study's third research question, focusing on certification readiness, yielded compelling evidence of CAA effectiveness. The 24% increase in certification pass rates and improved portfolio scores validated the assessment alignment with professional standards, such as SKKNI in Indonesia, addressing a critical gap noted by Brown (2024). External assessors confirmed these results, though their observations about creative homogenization introduced a nuanced caveat. This finding diverges somewhat from the optimistic projections in the literature about seamless integration of competency-based assessments in creative fields (Nusri et al., 2025), suggesting that while technical proficiency can be systematically enhanced, creative innovation may require supplemental pedagogical strategies.

The unique contribution of this study lies in its holistic integration of IRT within a creative discipline, bridging theoretical frameworks with practical implementation. While prior research has explored IRT in cognitive domains (Embretson & Reise, 2013) and PjBL in skill-based education (Thomas, 2000), this study synthesizes these approaches to address the specific needs of the photography course. The use of computer vision for automated compositional analysis further advances the discourse on technology-enhanced assessments (Jin et al., 2025), offering a scalable solution to reduce subjectivity in performance evaluations. However, the study also highlights unresolved tensions, particularly the trade-off between standardized competency development and creative expression, which future research must address.

In conclusion, the CAA represents a significant step forward in competency-based education, offering a validated framework for adaptive assessments in creative disciplines. Its alignment with industry standards and ability to enhance learning outcomes position it as a valuable tool for modernizing vocational education. Yet, the study also calls for caution in over-relying on algorithmic assessments, advocating for a balanced approach that preserves the artistic integrity of creative fields. These insights contribute to the broader movement toward equitable, personalized, and industry-relevant assessments while underscoring the importance of continuous refinement to address the complex interplay of technical and creative competencies.

LIMITATIONS

The limitations of this study lie in the fact that the developed model is still in the prototype stage; therefore, its widespread implementation cannot yet be carried out. In addition, the product has not been integrated into the assessment portal, requiring the manual entry of assessment results.

CONCLUSION

This study successfully developed and validated the Competence-Adaptive Assessment (CAA), demonstrating its efficacy in bridging the gap between academic evaluations and professional standards for junior photographers. By integrating IRT, the assessment achieved significant improvements in learning outcomes, certification readiness, and technical skill mastery, aligning with broader trends in competency-based education. However, the findings also revealed critical limitations, such as the model's struggle to fully capture creative judgment and the technical challenges of implementation, echoing concerns in the literature about algorithmic constraints in artistic disciplines. These limitations suggest that while CAA provides a robust framework for standardized skill assessment, it must be complemented by human evaluation to preserve creative innovation. Future research should explore hybrid models that combine adaptive testing with qualitative rubrics for artistic merit, as well as investigate longitudinal impacts on career progression. Additionally, expanding the model to other creative fields could test its generalizability. The study's implications extend beyond the photography learning course, offering a template for competency-driven reforms in vocational training while advocating for balanced approaches that honor both technical and creative dimensions of learning.

AUTHOR CONTRIBUTIONS

N contributed to conceptualization, methodology design, data collection (interviews, surveys, and observations), formal analysis, writing of original draft, project administration, literature review, data validation, review, and editing. LCS contributed to the interpretation of results, acquisition of funding, final proof-reading of the manuscript, handling of journal correspondence, visualization, preparation of figures, and preparation of tables.

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