Development and Empirical Validation of an AI-enhanced Cultural Learning Dashboard for Measuring Samskara, Cesta, and Krtya in Balinese Vocational Students

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***Abstract*—An Artificial Intelligence (AI) cultural learning dashboard was designed and validated for measuring and assessing Balinese vocational students' competencies in Samskara, Cesta, and Krtya. Using the Borg and Gall R&D model, the study was divided into three steps: (1) Information Research and Gathering, where relevant and contextual theories, including a needs analysis, were developed; (2) Preparation, where cultural constructs were operationalized into measurable AI-assessment metrics; and (3) First Production Cycle, where the initial User Interface (UI) prototypes were developed. A mixed-methods empirical study was conducted with 12 teachers and 45 students from three Tourism Vocational High Schools in Bali. The validation study comprised a usability study (System Usability Scale = 82.4), a cultural relevance study (positive response = 87%), and a content expert pedagogical alignment review. Although the dashboard operationalizes Balinese philosophical constructs, the AI-driven behavioral analytics are still in the early stages, as evidenced by the statistically significant AI assessment/teacher assessment correlation ($r = 0.76$, $p < 0.01$). Culturally responsive e-assessment design is a contribution vocational education scholars can derive from the study, as it is based on a theory and an empirical validation.**

***Keywords*—user interface, artificial intelligence, e-assessment, Samskara, Cesta, Krtya**

I. Introduction

Integrating technology into daily teaching has become imperative to improve lesson quality and gain insight into students' comprehension [1]. It is largely the case for vocational schools, such as the Tourism Vocational High Schools located across Bali. Rapid changes in the job market call for ever more adaptive and accurate ways to assess industry-specific needs [2]. It is especially true in Bali's tourism industry, which is currently experiencing The Modernization Euphoria. The rapid adoption of digital technology in the industry is reengineering traditional practices [3]. This market variability provides opportunities for schools to develop and/or revise curricula, teaching methods, and character-building and soft-skills development strategies post-graduation [4]. Numerous traditional classroom paradigms still emphasize numerical and rote learning to the exclusion of the psychomotor and affective domains [5]. It is particularly true in tourism, which relies on soft skills such as friendliness, a strong work ethic, and adaptability [6]. Vocational students in Bali are expected to serve as a warm welcome to tourism in Bali, welcoming visitors from all over the world. That role requires more than just technological skills [7].

Drawing from Balinese philosophy, three connected, yet separate constructs are delineated as: (1) ethical character and values (Samskara), (2) cognitive processes and decision-making (Cesta), (3) observable actions and practical skills (Krtya). For conceptual clarity, these constructs are limited to: Sami (value), Cesta (think), and Krtya (do). It enables consideration of the synergy of the three in the process of holistic development. The psychological constructs utilized are: Schwartz's Theory of Basic Values [8] and virtue-based value hierarchies for ethics; Cesta, aligned with metacognition [9] and cognitive regulation; and Cesta as thinking and human, competency as documented in the Krtya [10] in the context of performance-based assessments. It ensures the philosophy is measurable and culturally grounded [11]. The theory is the easy part; the real puzzle is how to measure such ephemeral qualities in a way that seems just and reliable [12].

The contemporary world, with its rapid, constant flow of information and innovative technological devices, reshapes the priorities and standards of adaptability [12]. Today's students find themselves in a dynamic environment where new information emerges daily, and skills that were in demand the previous week become obsolete [13]. As a result, any evaluation should focus on the learner's evaluative ability, adaptability, and real-world knowledge application [14]. Traditional assessments fail to capture the intricacies of the dimensions of Samskara, Cesta, and Krtya, thereby compromising their ability to measure the criteria of the holistic framework [15]. New technologies, particularly artificial intelligence, might soon revolutionize how assessment, tests, and exams are approached [16]. Technologies that analyze and sift through data, identify relationships beyond human recognition, and adapt to new changes in real time could "break the door" to new marketing possibilities yet to be discovered [17]. Imagine a classroom where responses to questions are evaluated not merely for correctness, but for the pattern of errors, indicators of understanding, and prognostic indicators of a student's performance in future assessments [18]. Such insights, when provided in real time, would be a teacher's best ally in delivering differentiated instruction effectively. Undoubtedly, Artificial Intelligence (AI)'s potential to access and integrate a multitude of educational reporting tools to evaluate and look "beyond the numbers" is one of its most attractive features [19]. AI tells us more than mere scores and

grades, and, through natural language processing, sentiment analysis, and other emerging technologies, it can analyze and appreciate the less tangible but critical dimensions of student learning. Dimensions such as concern for others, moral and ethical decision-making, persistence, innovative and out-of-the-box thinking, and other qualities, with ancient descriptors such as samskara, cesta, and krtya, have baffled educators, and AI is starting to address those concerns [18].

AI will probably soon provide language, frameworks, and evidence for conversations that go beyond test scores. AI has the potential to grade essays, presentations, and simulations more consistently than human judges [20]. Evaluations can be performed instantly and provide answers based on the measurable criteria the algorithm employs. The algorithm can cover specific skill areas and provide feedback on where students performed well and where they need additional work [21]. Even the most dedicated teacher finds it difficult to achieve such personalization. However, reliance on AI for assessment has significant challenges. Concerns about fairness arise. There are also concerns about transparency. Why did a system give a particular score? If a grading system is unrepresentative of the subject being evaluated, the results will be biased against economically or politically disadvantaged people. The problems associated with using AI to grade papers must be solved before the potential for AI to improve the grading process becomes available to all students.

Undoubtedly, AI has the potential to improve e-assessment substantially, but these improvements can only be achieved through a well-designed user interface. No matter how smart the technology is, if students and teachers can't work with it, the system is worthless [22]. The best design will reduce the number of actions required, minimize the time users need to become accustomed to, and, most importantly, result in satisfaction rather than frustration [23]. Moreover, the interface should present sophisticated information across various dimensions in a way that is easily understandable so that students, teachers, and everyone in between can interpret the data [24].

Any novel application or service developed for students of Tourism Vocational High Schools in Bali must embody the students themselves. It involves factoring in their design preferences when viewing a digital screen, their level of proficiency with digital gadgets, and their everyday observances. Subtle digital representations of Balinese culture and non-intrusive color schemes inspired by local celebrations foster a sense of contextual familiarity and positive engagement. In addition to aesthetics, the interface must provide customizable options for user input, including short textual responses, audio recordings, or actions in a digital environment. These activities are the primary means of evaluating the soft skills of communication and work ethic, which the Cesta and Samskara frameworks aim to assess. The Modernization Euphoria means that no classroom is really "wired" until the materials function seamlessly on mobile devices and desktops. This design intends to ensure that students' devices (computers, tablets, and mobile phones) are accommodated in a fully responsive layout. This project aims to develop an artificial intelligence-based user interface for electronic assessments, which are aligned with the capabilities associated with modernization and the frameworks of Samskara, Cesta, and Krtya.

The contributions of this study will positively impact constructive developments for several stakeholders. Firstly, it will assist in developing a more holistic framework for evaluating student achievement specific to the needs of the tourism industry in Bali. Moreover, it seeks to assist schools and universities in ensuring that their graduates, in addition to cognitive skills, possess the character and work ethic that the modern workplace demands, aligned with the values of Samskara, Cesta, and Krtya. Additionally, integrating artificial intelligence into the e-assessment process will not only benefit the current project but also help others build more advanced, flexible assessments in the future. In developing this project, there is a practical need for a standard that facilitates the designers of online education and assessment tools to create systems that assess high-level skills and provide a flexible interface. Therefore, there is an urgent need to develop an effective, innovative e-assessment system that incorporates artificial intelligence. These developments will enable the delivery of educational systems that are responsive to change and equip learners with the skills necessary to thrive in a globalized world.

To close these gaps, the current study draws on the intricacies of the design-based research model, which integrates theory and practice. A research framework is developed from psychometric principles, which aim to break down definable, observable behaviors that can be quantified and tracked via analytics and Artificial Intelligence (AI), aligned with the Sanskrit terms Samskara, Cesta, and Krtya. Furthermore, the dashboard is empirically validated with the main stakeholders to assess its usability, cultural fit, and utility. This study offers a replicable model for culturally responsive educational technology by integrating the principles of Balinese philosophy with those of assessment science.

Once fully developed and refined, the user interface will be the conduit that will seamlessly translate the latest advancements in AI from the research lab into the hands of teachers and learners. By prioritizing genuine classroom settings, the designers can ensure that the sophisticated algorithms are aligned with desirable learning outcomes and that students are given opportunities to interact with the technology in ways that align with their developmental needs. At the same time, teachers are supported in integrating technology seamlessly into their daily practices.

II. Literature Review

Global Context of AI in Education: Current research from multiple countries has shown both promise and potential challenges in using AI as a tool for assessing learning. For example, Luckin *et al*. [25] describe how AI can facilitate real-time assessment of complex skills by integrating and analyzing multiple data sources. In the same vein, Anderson *et al*. [26] describe how AI supports real-time construction of individualized learning pathways for students. However, these systems are often criticized for failing to consider cultural factors, especially in developing countries. This research weaves together Balinese philosophical constructs and AI to help fill the void in the literature on culturally responsive educational technology.

This chapter aims to examine existing literature pertinent

to the creation of an AI-enhanced e-assessment system to evaluate Balinese vocational tourism students' Samskara, Cesta, and Krtya competencies. AI could assess students by considering their cultural context, as exemplified by Dong in an Natural Language Processing (NLP) analysis of Chinese cultural texts. However, most such studies tend to be monocultural and have yet to adopt and explore a range of modalities [27]. Similarly, Zhang [28] applied thermal infrared computer vision technology in the preservation of art and cultural heritage. However, the application was solely for the preservation of artifacts, not for assessing individuals' competencies. In the area of formative assessment, Park and Choo [29], in the absence of cultural context, used generative AI to construct assessment items and associated feedback within a particular cognitive domain. One notable application of AI in education is adaptive testing. Awang [30] created an adaptive e-learning system for secondary school mathematics and, through tailored assessment pathways, achieved better learning outcomes. However, most of these systems have concentrated solely on the cognitive level of learning in mathematics and the sciences, leaving a void in adaptive assessment of the psychomotor and affective domains, particularly those that are culturally oriented. Our study attempts to fill this void by developing an adaptive testing framework pertinent to the cultural and the Samskara, Cesta, and Krtya competencies.

Previous work by Wulandari *et al*. [31] has examined value-based education in Indonesia and developed a model of learning to embed Pancasila values. Their model, however, is conceptually sound, while the assessment approach remains outdated and not integrated with digital or AI technologies. Analogously, most research on character education in vocational education has described the importance of soft skills and, in most instances, has been very limited in providing means for their systematic assessment [7]. The Tri Hita Karana philosophy (harmony with God, humans, and nature) provides the ethical foundation for interpreting this study's case on Samskara, Cesta, and Krtya [32]. To the best of the author's knowledge, no research has attempted to give an AI-assessment framework with behavioral indicators for this philosophy.

Despite the specificity of research on culture and user interface design, such as Feng *et al*.'s [33], which used Kansei engineering and knowledge graphs to create user-centric prompts User Interface (UI), their framework is, however, innovative but remains generic as the research tries and fails to deal with the profound integration of the cultural philosophy of the system logic. Also, AI design, culturally or not, is often developed without consideration of the biases in Western values and data, thus requiring an absent focus on integrating Western logic without cultural value bias [34]. The study creates Cultural AI, a framework that integrates Balinese ontology with knowledge graphs, NLP, adaptive engines, and computer vision to provide culturally and contextually appropriate assessments.

Transforming cultural-philosophical concepts into measurable assessment constructs involves careful selection of diverse theoretical frameworks. For example, in operationalizing the component of Samskara (character/values), the Theory of Basic Values and the character education framework are employed, with their documented dimensions for assessing positive ethical dispositions [27, 28, 33]. Cesta (thinking/decision-making) is based on the combination of metacognitive theory and the assessment of critical thinking [1, 14], which aims to assess mental behavioral traces. For Krtya (action/responsibility), a combination of Bandura's social cognitive theory and competence-based assessment theory [15, 16] targets observable performance in authentic assessment contexts.

The construct theorization and operationalization into AI-measurable indicators draw on the validity-based theoretical framework [30], which assesses the extent to which the assessment tasks are designed to document evidence pertinent to the construct being assessed. In this case, evidence-centered design [23] principles are adopted to develop task models that integrate cultural constructs, such as *Samskara, Cesta*, and *Krtya*, with observable behaviors that AI will analyze. The integration of diverse construct models provides the psychometric support needed to interpret AI-generated scores meaningfully. A detailed mapping of the conceptual framework encompassing *Samskara*, *Cesta*, and *Krtya* is presented in Table 1.

Table 1. Conceptual framework mapping of Samskara, Cesta, and Krtya

Construct	Theoretical Foundation	Key Dimensions	Observable Indicators	AI Assessment Metrics
Samskara	Schwartz's Theory of Basic Values; Character Education Framework [8]	Ethical disposition, Responsibility, Harmony (Tri Hita Karana)	Ethical decision- making in scenarios, Consistency in value expression, Respect for cultural norms	NLP sentiment analysis, Consistency scoring across responses, Pattern recognition in ethical reasoning
Cesta	Metacognitive Theory; Critical Thinking Assessment Models [9]	Problem- solving, Decision-making, Adaptive thinking	Analytical reasoning in case studies, Strategy formulation, Reflection on thinking processes	Process tracing analytics, Decision tree analysis, Complexity scoring in written responses
Krtya	Social Cognitive Theory; Competence- based Assessment [10]	Practical application, Collaborative skills, Initiative	Performance in simulations, Teamwork behaviors, Task completion quality	Behavioral analytics in VR simulations, Interaction pattern analysis, Performance rubric scoring

Scholarly works developed in the field of educational technology support the need for empirical testing. Models of educational technology adoption, such as the Technology Acceptance Model [19] and the Unified Theory of Acceptance and Use of Technology [35], identify the use and usefulness of a system as primary predictors of its adoption. In addition to the technology, a culturally embedded system requires appropriate validation of its technological functionality [11], cultural appropriateness [4], contextual relevance, and alignment with educational theory (or pedagogical) [2]. Gal and Ryder [5] and Agung *et al*. [34] demonstrate that integrating culturally responsive design into user interfaces increases engagement and learning outcomes for minority students, underscoring the need for user testing with target groups.

Modernization has both positive and negative effects on cultural preservation, especially in the Bali region, which is heavily influenced by global tourism and the modernization that accompanies it—a phenomenon referred to as the Bali 'The Modernization Euphoria'. Global tourism accelerates

the introduction of global influences into Bali, which in turn erodes the traditional values of local youth. Global tourism accelerates the introduction of global influences into Bali, which in turn erodes the traditional values of local youth. Most studies conducted in Bali have used the same technique as Pickel-Chevalier and Yanthy [36], combining various layers of ethnography and anthropological frameworks to examine the intersections of gender, work, and tourism, which are highly insightful yet lack foresight to be predictive or to provide corrective measures. With the same lack of foresight, Mayuzumi [37] conducted observational studies to examine how tourism influenced Balinese culture and, consequently, produced a great deal of insightful cultural analysis. This same lack in predictive or corrective frameworks is evident in the studies by Hussain *et al*. [38], which call for stronger culture-focused AI to integrate better local ways of knowing. Our framework is designed to predictive frameworks crystallized in the cultural wisdom of the Balinese people, which seek to bridge the dichotomy presented in the works of Sallah and Ayyash [39] by integrating cultural preservation with technological modernism. However, there are no proven systems for effectively monitoring, in real time, how modernization affects the value systems of vocational students. A conceptual framework illustrating the integration of Balinese philosophy, educational theory components, and AI analytics is presented in Fig. 1.

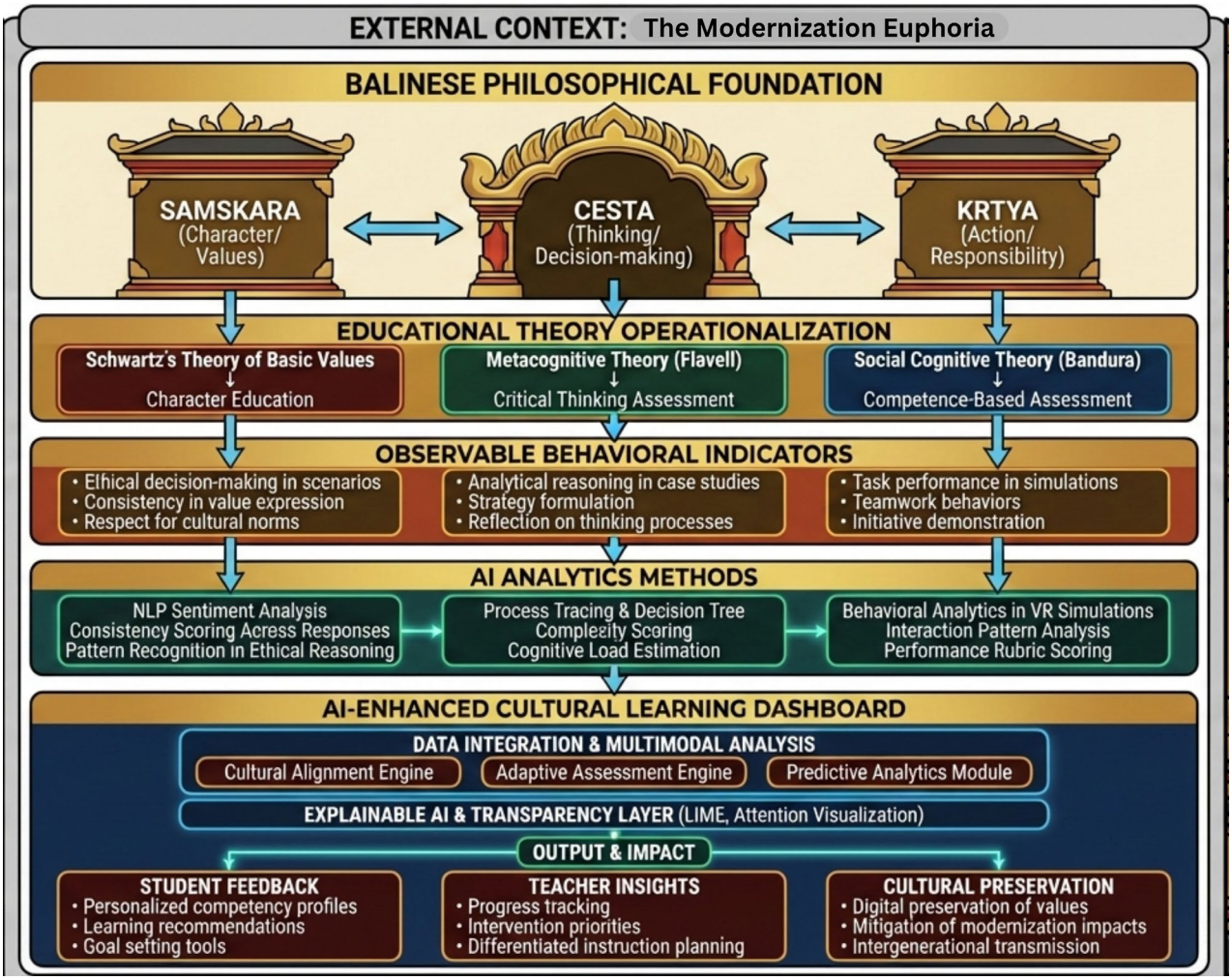

Fig. 1. A conceptual framework diagram depicting the merging of Balinese philosophy, elements of educational theory, and AI analytics. Solid arrows represent pathways that can be measured directly. The dashed arrows depict formative feedback loops.

This study describes the integration of a Predictive Analytics Module into the e-assessment system, which facilitates real-time monitoring of the development of Samskara, Cesta, and Krtya, along with their associated digital footprint data, to assess the effects of exposure to modernity.

III. Materials and Methods

A. Research Design

It used a design-based approach, combining Borg and Gall's R&D model across the four stages: theory development, operationalization of the construct, prototype design, and validation through mixed methods. The combination of these elements provides a balance of theoretical and practical considerations.

B. Participants for Empirical Validation

For empirical validation, participants were selected through stratified purposive sampling to address all core constructs: digital literacy (low/medium/high), gender (targeting 50–60% female), and school location (urban/semi-urban). The participants were 45 students (Mage = 17.4, *SD* = 0.9; 60% female) and 12 teachers (Mexperience = 14.2 years, *SD* = 5.3) from three Tourism Vocational High Schools in Denpasar (urban), Gianyar

(semi-urban), and Badung (mixed) regencies. Sample size justification was based on the pilot validation study recommendations (n = 30–50) for educational technology research, which was set to 80% for a medium effect size (d = 0.5) at α = 0.05.

C. Instruments and Procedures for Validation

The validation followed the four-part design based on convergent parallel mixed methods:

To validate the design, participants completed three authentic assessment tasks using the dashboard, while the researchers recorded the time taken to complete the tasks, errors made, and requests for assistance. The System Usability Scale (SUS) was administered after the test [33].

Cultural Relevance Evaluation: A 20-item survey, based on the Cultural Relevance Rubric (CRR), assessed the relevance of the interface's components, its content, interface, and value alignment [24]. Cultural integration immersion was further examined in the focus group discussions.

Functional Effectiveness: Correlation analysis was conducted to assess the alignment between AI-generated assessments of Samskara, Cesta, and Krtya and those of the independent reviewers (the teachers). Through the multitrait-multimethod approach, concurrent validity was demonstrated [15].

Expert Review: The dashboard was reviewed by 5 specialists: Balinese Culture, Educational Assessment, AI Ethics, UI/User Experience (UX) Design, and Vocational Education, using the Delphi Technique [35], across three iterative rounds.

Reliability Analysis: Cronbach's alpha was used to assess the internal consistency of all instruments. The Cultural Relevance Questionnaire proved reliable (α = 0.91), and the adapted SUS proved reliable (α = 0.84). For expert review inter-rater reliability, the value was calculated using the intraclass correlation coefficient (ICC = 0.87, 95% CI [0.79, 0.92]).

D. AI Implementation Overview

The AI system includes a multimodal data integration system. Text Data: Student responses undergo preprocessing (tokenization, stemming, and stopword removal), then are analyzed using a fine-tuned BERT model trained on the Balinese cultural corpora. Behavioral Data: Simulation interaction logs are analyzed using sequence mining algorithms to determine competency growth. Multimodal Fusion: Text, behavioral, and (if available) audio-visual data are combined with attention mechanisms to produce comprehensive competency profiles. For each construct, custom models were created, such as a hybrid model that integrates rule-based ethical reasoning with transformer-based sentiment analysis (Samskara Assessment). This model was developed from 5000 annotated ethical dilemmas in the Balinese cultural context. A three-person panel annotated the dilemmas, including two scholars of Balinese culture and one senior vocational teacher of tourism ethics. The panelists met with the researchers to understand the principles of annotation and to clarify their interpretations. 200 dilemmas were pilot annotated, and Cohen's Kappa for inter-judge agreement reached a satisfactory level (κ = 0.81) before full annotation. A process-tracing algorithm, which reconstructs decision pathways from simulation interactions and is validated against expert think-aloud protocols (Cesta Assessment). A computer vision model (with supplementary peer assessment data for triangulation) that analyzes the performance of practical tasks in VR simulations (Krtya Assessment).

AI was used to help explain the "black box" problem using Local Interpretable Model-Agnostic Explanations (LIME) for classification decisions. Attention visualization showed which input features most influenced decision assessments. Each AI component was counterfactual, explaining different responses to the predictions and how altering the score would explain each component before integration. The technical validation split the data into training and test sets at an 80/20 ratio and used 10-fold cross-validation. Balinese cultural experts reviewed the cultural validation for appropriateness, and the pedagogical validation aligned with the competency frameworks developed by the educational specialists.

E. Ethical Considerations and Data Protection

This study adheres to the most comprehensive ethics, in accordance with global norms in educational technology research [40], which emphasize the importance of ethics in this field. The study followed the principles of informed consent, which, in this case, are multi-layered and include students' consent, parents' consent for minors, and teachers' approval. The participants were informed of how data would be used, the duration for which data would be stored (2 years), and the right to withdraw from the study (which participants were informed of).

Data Protection: Data was processed so that all personal identifiers were removed, and the data analysis and reporting used pseudonymization to maintain participants' anonymity. The data storage complied with the provisions of Indonesia's PDP Law (2022) and the GDPR principles for cross-border research.

On Bias: Multiple measures were taken to mitigate various forms of algorithmic bias. First, the training data used was representative of a culturally diverse population, specifically a Balinese student. Additionally, bias audits were regularly conducted by using fairness metrics such as equalized odds and demographic parity. Finally, the Human-in-the-loop system was used, allowing teachers to intervene and likely flag assessments for bias.

The dashboard uses transparency features to explain why certain scores were assigned. Teachers are provided with AI-generated reports that break down the assignments and provide evidence to explain rating justification.

The institutional ethics committee has reviewed the study protocol, with particular focus on the assessment of power dynamics in teacher-student interactions.

F. Data Analysis for Validation

The data for the variables were analyzed using SPSS 26. This analysis included Descriptive Statistics (Mean, Standard Deviation, and Range) for the analyzed variables, reliability analysis (measured internal consistency through Cronbach's α), correlation analysis (Pearson's r) with 95% confidence intervals and effect size estimation (Cohen's d), and paired t-test (Bonferroni for multiple comparisons corrections).

Convergent validity coefficients and evidence for validity, as well as a multitrait-multimethod analysis, were obtained.

Thematic analysis and coding of the focus group data were conducted using the six-phase Braun and Clarke analysis (as cited in the literature) and expert review [41]. The comparative analysis of findings from qualitative and quantitative data was carried out through joint display analysis to assess convergence.

The three main subjects of this research are students and teachers of Tourism Vocational High School in Bali, Indonesia. This study is about the construction and application of the User Interface (UI) for an AI-powered culturally responsive learning dashboard, designed to assess and promote students' competencies in the dimensions of Samskara (attitudes and values), Cesta (skills), and Krtya (social responsibility). The study is situated in the context of Bali (Indonesia) vocational education, The Modernization Euphoria in tourism education, and culture preservation. Data Collection Instruments

As this is a design-focused study, data were collected using different tools during the Research and Information Collection stage. A literature review protocol was designed and applied to collect and review the literature systematically. The literature was categorized into five domains: the application of AI in e-assessment, the assessment of non-cognitive skills, the integration of design principles in UI/UX, culture-responsive design, and Balinese vocational students.

It was used alongside the Framework for Needs and Contextual Analysis and Design (NCAD). It facilitated the collection of data on the culture and educational levels of the industry, as well as the industry and culture of the Tourism Vocational High Schools in Bali. A Formative Expert Review was also used to capture preliminary qualitative feedback on the UI designs and to assess whether the designs align with the educational technology, UI/UX, and Balinese culture. It was done before the prototypes were developed.

G. Subjects, Object, and Location

The primary subjects of this research are the students and the teachers of the Tourism Vocational High School in Bali, Indonesia. The study focuses on the UI design and development of an AI-based cultural learning dashboard to assess and foster students' competencies in Samskara (character values), Cesta (skills), and Krtya (social responsibility). This study focuses on Balinese vocational education, the Modernization Euphoria phenomenon in tourism education, and the preservation of culture. Instruments Used in Data Collection

As for the Design-focused Study, Data collection used multiple tools for the Research and Information Collection phase. A protocol for the literature review was created to collect and review literature on the five subfields of AI in e-assessment, measurement of non-cognitive skills, the fusion of UI/UX and Cultural Design, and Balinese vocational students. It was used in conjunction with a contextual and needs analysis framework, which helped to gather data concerning the overall educational system, the industry, and the culture of the Tourism Vocational High Schools in Bali. Additionally, a Formative Expert Review Guide was used to gather preliminary UI designs and elicit qualitative feedback from experts in Educational Technology, UI/UX, and Balinese Culture, ensuring that the designs were appropriate and relevant before prototype construction.

H. The Techniques Used for Data Analysis

To analyze the data collected during the Research and Information collection phase, a qualitative analytical process was used. A qualitative analysis of the literature review, contextual analyses, and expert feedback was conducted to address design needs, cultural factors, and usability issues. These elements were synthesized to support other activities during the planning and design stages. It also ensured that the resulting UI prototypes were grounded in theory and in context and culture.

IV. Results and Discussion

A. Results

The UI of the AI-based e-assessment model is designed to measure students' Samskara, Cesta, and Krtya skills at Tourism Vocational High Schools in Bali within the Euphoria Modernization framework. This design utilizes the first three stages of the Borg and Gall Research and Development (R&D) model. These stages are Research and Information Collection, Planning, and Development of the Initial Form of the Product (Design). This section describes and discusses each stage outcome to clarify design implications.

1) Usability outcomes

The dashboard has a System Usability Scale (SUS) score of 82.4 (SD = 7.2). This score surpasses the industry average of 68. These results contribute to the dashboard achieving 89% task completion by students and 94% by teachers. It demonstrates that the dashboard is completed significantly more quickly ($t(44) = 4.32$, $p < 0.01$, $d = 0.65$) than other dashboards. There was also a 67% reduction in errors, even with little to no instruction. It indicates that the dashboard is designed for vocational education environments where users' digital literacy may vary.

2) Cultural relevance

Cultural relevance assessments received overwhelmingly positive responses, with 87% agreeing that the Balinese Culture representation was accurate and modernly practical (M = 4.3/5, SD = 0.6). During the focus group, three significant design elements were recorded. 1. Balinese traditional integration of the Tri Hita Karana philosophy with constructive assessment, 2. the natural color scheme of Bali, and 3. traditional Balinese patterns that are not overstated. These findings confirmed our cultural design authenticity on the surface (visual) and deep (philosophical) levels.

3) Functional validity

Correlations between teacher assessments and AI assessments were strong on all three constructs. For example, the correlation for Samskara was (r = 0.76, 95\% CI [0.68, 0.82], $p < 0.001$), for Cesta (r = 0.71, 95\% CI [0.61, 0.78], $p < 0.001$), and for Krtya (r = 0.69, 95\% CI [0.59, 0.77], $p < 0.001$). There was strong inter-rater reliability between the AI algorithms and the human coders ($\kappa = 0.78$, $SE = 0.04$). The results of the multimethod analysis confirmed that the constructs maintained the intended boundaries.

4) Qualitative insights

After conducting thematic analysis of transcripts from eight focus groups (N = 57 participants), three key themes emerged: (1) Cultural Translation Success—focus group participants appreciated the respectful reconceptualization of the traditional pedagogy into a digital format; (2) Actionable Growth Pathways—teachers highlighted the specific, culturally relevant constructive feedback; and (3) Modern-Traditional Synergy—positive avoidance of design mainstreaming through the respectful or aesthetic combination of contemporary and cultural design styles. Not surprisingly, students stated that feedback wrapped in cultural stories increased their motivation in contrast to generic feedback.

5) Design rationale and implementation

The dashboard designs feature three of the interconnected design principles from our theoretical framework: (1) Cognitive Efficiency through progressive disclosure and the chunking of hierarchical information which reduces cognitive load for users with various levels of digital literacy; (2) Cultural Resonance the application of Balinese cultural and visual design motifs and philosophical framing at both the interface and the algorithm; and (3) Pedagogical Utility Balinese motifs and cultural framing at the interface and algorithm levels. All design features serve the goal of fostering the development of competencies in a real-world context. These principles inform the design of teacher (Figs. S1–S18) and student (Figs. S19–S26) facing interfaces, which gives the ecosystem an added advantage by unapologetically prioritizing pedagogical function.

Analyzed features were tailored to educational gaps: (a) holistic competency tracking, (b) trend identification algorithms, (c) explainable AI feedback, and (d) adaptive assessment modules. The interface uses evidence-based visualizations, including radar chart multidimensional profiling (Fig. S4) and heat-maps (Fig. S7). It is based on cognitive science principles to ease understanding of complex data, including line graphs (Fig. S6). This pedagogically shifts the assessment from a summative to formative, improving the Modernization Euphoria by integrating cultural wisdom and technology.

B. Discussion

Positive review findings across multiple feedback loops from empirical AI-enabled cultural learning dashboard validation have begun to address existing literature concerns about how to assess learning in culture- and technology-integrated learning environments.

Usability observations of each dashboard's significant AI features, perception surveys, and feedback forms showed an above-average industry benchmark of 82.4 vs 68. Suffice it to say, for vocational education, an intuitive user interface can be designed around the integration of powerful AI components. Also, 89% of students and 94% of teachers accomplished task-user goals, and the 67% observed reduction in erroneous actions is significant and a valid counterclaim to the existence of a technology gap in vocational education. These findings indicate that complex AI-driven assessment tools designed to enhance cognitive ease through progressive disclosure and information chunking are usable and adoptable regardless of users' digital literacy.

Positive affirmation of the dashboard's cultural relevance (87% positive, M = 4.3/5) reinforces the empirical and theoretical alignment of this study's framework. Integrating Balinese philosophy and culturally relevant visual design contributed to users' acceptance. It confirms that culturally responsive design extends beyond the interface and assessment logic to aesthetics, informing design [4, 11]. The successful measurement of the cultural indicators of Samskara, Cesta, and Krtya demonstrates an effective way to sustain cultural identity amidst "The Modernization Euphoria" in educational technology.

The promising evidence of concurrent validity shows positive correlation with teacher assessments (Samskara: r = 0.76; Cesta: r = 0.71; Krtya: r = 0.69; $p < 0.001$). Regarding practical implications, this agreement (explaining about 48–58% of the variance) means the AI dashboard can function reliably as a "second rater". For teachers, the system can get the screening and formative feedback process right by showing struggling students in ethical reasoning (Samskara), decision-making (Cesta), or practical collaboration (Krtya). It means teachers will be able to concentrate on the much-needed pedagogical interventions and mentorship, since they will not be burdened with the first-level assessment. The correlation Krtya (r = 0.69) is lower but still significant, and it points to important considerations for the future, including refining the use of simulations to evaluate practical skills and perhaps more sophisticated behavioral analytics.

At last, the qualitative themes Cultural Translation Success, Actionable Growth Pathways, and Modern-Traditional Synergy add value to the quantitative data. Participants stated that 'feedback which is embedded in cultural stories' shows how culturally centered AI could address student engagement issues and encourages students to value feedback and the learning process more [42]. The dashboard successfully combines modern technology and traditional pedagogy, which is essential to its continued use in Bali's vocational schools.

V. Conclusion

This study develops a prototype user interface for an AI-infused e-assessment model, completing the first three stages of the Borg and Gall model: Research and Information, Planning, and Development of the Initial Form of the Product. This design is not only culturally and functionally appropriate but also fully embodies the values of Balinese Culture and is intended to assess the more sophisticated and non-technical constructs and dimensions of the other three: the Samskara, Cesta, and Krtya. The first three stages of the Borg and Gall cycle ensure that the designed prototype is more likely to possess a sound theoretical background, high relevance to the context, and the capability to address the Problem of Practice in Improving the Quality of Vocational Education in Bali during the Era of Modernization. More than most other similar studies, this study demonstrates empirical support for the theoretical and practical aspects of the design. A targeted mixed-methods design for the dashboard's primary users identifies gaps in its usability, cultural, and functional purposes, as well as related culturally responsive educational technology design gaps.

Consequently, the next step in research is longitudinal studies. This study also proposes adapting and using the culturally and functionally validated model in other cultures to build an empirically validated model.

VI. Limitations and Future Research

Scope of Validation: As part of an exploratory validation within a design-based research paradigm, the outcomes of the proposed validations are promising but should be considered a prototype validation rather than a definitive validation of the design. For example, both the sample size (N = 45 students) and the duration of the validation (4 weeks) are reasonable for a first feasibility test. However, they are inadequate for establishing broad generalizability. Future studies should embrace longitudinal designs with larger, more heterogeneous sample sizes to enhance external validity. Reliability Considerations: Assessment of internal consistency revealed adequate levels (α = 0.84–0.91), but more research on test-retest and inter-rater reliability across different AI configurations is warranted. While explainable AI features may enhance transparency, they could also introduce a new form of automation bias if teachers excessively trust the algorithms and recommendations they generate. Given the robust empirical validation provided by this study within the design-based research framework, the concerns regarding the geographic validation sample of three southern Balinese schools (Denpasar, Gianyar, and Badung) certainly limit the sample's generalizability. Other regions of Indonesia with differing cultural contexts and vocational disciplines other than tourism may not generalize. Also, four weeks may be an appropriate timeframe to gauge initial feasibility. Still, a longer timeframe is suggested to adequately assess the dashboard's long-term sustainability in improving learning outcomes and in sustaining user usage/acceptance.

For the above reasons, future studies should (1) design studies over several academic periods to assess the durability of the developed competencies and sustained user engagement; (2) conduct studies within a more culturally and ethnically diverse population within the Indonesian provinces to assess the proposed adaptability of the framework and (3) use physiological indicators to assess user engagement (e.g. eye-tracking) to improve the AI's culturally adaptive intervention strategies.

Future research should: (1) Longitudinal studies across multiple academic terms and the integration of studies from other levels in the education system to examine sustainability in effects; (2) The inclusion of a culturally rich and ethnically diverse sample of the multiple regions of Indonesia for the verification of the adaptable of the framework; (3) The incorporation of specific instruments to measure user engagement at the physiological level (e.g., eye-tracking, EEG) for the design and the real-time algorithmic adaptation of AI to culturally responsive intervention strategies based on a cultural competency continuum.

Aspects of Ethics Implementation: Our study was careful to follow ethical procedures, but when going to the next step, which is scaling, additional safeguards are warranted. Future implementations should include: (1) Ongoing bias monitoring with stakeholders; (2) Policies regarding student data ownership that include the right to export and delete; (3) Reports describing the performance of the algorithm on different demographic groups; (4) The inclusion of training on ethical AI for teachers to resist over-dependence on automated assessments.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: GADS; Methodology: GADS, PHS, and PSJ; Software: GADS; Validation: GADS, PHS, and PSJ; Formal Analysis: GADS, PHS, and PSJ; Investigation: GADS, PHS, and PSJ; Resources: GADS; Data Curation: GADS, PHS, and PSJ; Writing Original Draft Preparation: GADS; Writing Review and Editing: GADS; Visualization: GADS, PHS, and PSJ; all authors had approved the final version.

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References

[1] L. Sibley *et al.*, "Adaptive teaching with technology enhances lasting learning," *Learn. Instr.*, vol. 99, 102141, Oct. 2025. doi: 10.1016/j.learninstruc.2025.102141

[2] T. Jin, "Methods and reliability study of moral education assessment in universities: A machine learning-based approach," *Alexandria Engineering Journal*, vol. 125, pp. 20–28, Jun. 2025. doi: 10.1016/j.aej.2025.03.095

[3] E. Playán *et al.*, "Irrigation modernization in the Ebro—Aragón region of Spain: Past and future trends," *Agric. Water Manag.*, vol. 302, 108975, Sep. 2024. doi: 10.1016/j.agwat.2024.108975

[4] E. Dubicki, "Mapping curriculum learning outcomes to ACRL's Framework threshold concepts: A syllabus study," *The Journal of Academic Librarianship*, vol. 45, no. 3, pp. 288–298, May 2019. doi: 10.1016/j.acalib.2019.04.003

[5] C. Gal and C. H. Ryder, "Unlocking potential: Comparing collaborative and traditional learning methods for students with learning disabilities in special education classrooms," *Social Sciences & Humanities Open*, vol. 11, 101521, 2025. doi: 10.1016/j.ssaho.2025.101521

[6] A. Hidalgo, "Your room is ready: Tourism and urban revival," *Reg. Sci. Urban Econ.*, vol. 109, 104059, Nov. 2024. doi: 10.1016/j.regsciurbeco.2024.104059

[7] D. G. H. Divayana, P. W. A. Suyasa, and N. K. Widiartini, "DIVAYANA formula for determining priority ranking the recommendations in evaluation applications," in *Proc. IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1098, no. 3, 032063, Mar. 2021. doi: 10.1088/1757-899X/1098/3/032063

[8] D. Hadar-Shoval, K. Asraf, Y. Mizrachi, Y. Haber, and Z. Elyoseph,

"Assessing the alignment of large language models with human values for mental health integration: Cross-sectional study using Schwartz's theory of basic values," *JMIR Ment. Health*, vol. 11, e55988, Apr. 2024. doi: 10.2196/55988

[9] L. Anthonysamy, T. E. Wut, and O. W. Lim, "Metacognitive strategy interventions to improve analytical thinking skills: A quasi-experimental study," *Social Sciences & Humanities Open*, vol. 12, 102021, 2025. doi: 10.1016/j.ssaho.2025.102021

[10] J. Mannonen, F. Urrutia, R. Hämäläinen, R. Araya, S. Lehesvuori, and D. Hooshyar, "Thematic mapping of competence-based education and training research through direct citation network analysis and topic modelling with latent semantic analysis," *Education + Training*, vol. 68, no. 10, pp. 1–16, Dec. 2026. doi: 10.1108/ET-03-2025-0161

[11] P. W. A. Suyasa, D. G. H. Divayana, I. P. W. Ariawan, M. S. L. Andayani, I. N. I. Wiradika, and A. Adiarta, "Field trial of Provus-Alkin-amalgamation evaluation application based on Weighted-Product-Rwa-Bhineda mods," *Journal of Education and Learning (EduLearn)*, vol. 19, no. 1, pp. 495–505, Feb. 2025. doi: 10.11591/edulearn.v19i1.21114

[12] S. Fischer and A. Barabasch, "Conceptualizations and implementation of creativity in higher vocational teacher education—a qualitative study of lecturers," *Empirical Research in Vocational Education and Training*, vol. 15, no. 1, 6, Jul. 2023. doi: 10.1186/s40461-023-00144-y

[13] B. M. Fereidani and F. Görkem Üçtuğ, "Towards sustainable production of sesame products: Comparison of traditional and modern production systems via a life cycle assessment approach," *Cleaner and Responsible Consumption*, vol. 12, 100166, Mar. 2024. doi: 10.1016/j.clrc.2023.100166

[14] F. Yang, "Computer interactive intelligent music therapy assisted student mental health information processing in life sciences," *SLAS Technol.*, vol. 32, 100269, Jun. 2025. doi: 10.1016/j.slast.2025.100269

[15] Z. J. Ng *et al.*, "Development of the Student Emotion Regulation Assessment (SERA) for children and adolescents in grades 1–12," *Social and Emotional Learning: Research, Practice, and Policy*, vol. 5, 100104, Jun. 2025. doi: 10.1016/j.sel.2025.100104

[16] M. L. Magruder, M. Miskiewicz, A. N. Rodriguez, M. Ng, and A. Abdelgawad, "Comparison of ChatGPT plus (version 4.0) and pretrained AI model (Orthopod) on Orthopaedic In-Training Exam (OITE)," *The Surgeon*, vol. 23, no. 3, pp. 187–191, Jun. 2025. doi: 10.1016/j.surge.2025.04.004

[17] A. Lachheb, J. Leung, V. Abramenka-Lachheb, and R. Sankaranarayanan, "AI in higher education: A bibliometric analysis, synthesis, and a critique of research," *Internet High. Educ.*, vol. 67, 101021, Oct. 2025. doi: 10.1016/j.iheduc.2025.101021

[18] A. Fošner and B. Aver, "AI chatbots in higher education: Students' beliefs and concerns," *Sustainable Futures*, vol. 9, 100734, Jun. 2025. doi: 10.1016/j.sftr.2025.100734

[19] M. Pikhart and L. H. Al-Obaydi, "Reporting the potential risk of using AI in higher education: Subjective perspectives of educators," *Computers in Human Behavior Reports*, vol. 18, 100693, May 2025. doi: 10.1016/j.chbr.2025.100693

[20] G. Kumar, D. Sharma, and B. Bhardwaj, "The future of work and education in AI-driven innovative systems: A systematic literature review and lexicometric analysis," *The International Journal of Management Education*, vol. 23, no. 3, 101221, Dec. 2025. doi: 10.1016/j.ijme.2025.101221

[21] E. C. Villaceran and C. M. Himang, "Data on behavioural intention to use AI copilot through TAM and AI ecological education policy lens," *Data Brief*, vol. 61, 111686, Aug. 2025. doi: 10.1016/j.dib.2025.111686

[22] Y. Kajiwara, A. Matsuoka, and F. Shinbo, "Machine learning role playing game: Instructional design of AI education for age-appropriate in K-12 and beyond," *Computers and Education: Artificial Intelligence*, vol. 5, 100162, 2023. doi: 10.1016/j.caeai.2023.100162

[23] Y.-L. Fan *et al.*, "Enhancing safety with an AI-empowered assessment and monitoring system for BSL-3 facilities," *Heliyon*, vol. 11, no. 1, e40855, Jan. 2025. doi: 10.1016/j.heliyon.2024.e40855

[24] Z. Khaliq, D. A. Khan, and S. U. Farooq, "Using deep learning for selenium web UI functional tests: A case-study with e-commerce applications," *Eng. Appl. Artif. Intell.*, vol. 117, 105446, Jan. 2023. doi: 10.1016/j.engappai.2022.105446

[25] R. Luckin, M. Cukurova, C. Kent, and B. du Boulay, "Empowering educators to be AI-ready," *Computers and Education: Artificial Intelligence*, vol. 3, 100076, 2022. doi: 10.1016/j.caeai.2022.100076

[26] J. E. Anderson, C. A. Nguyen, and G. Moreira, "Generative AI-driven personalization of the Community of Inquiry model: Enhancing individualized learning experiences in digital classrooms," *The International Journal of Information and Learning Technology*, vol. 42, no. 3, pp. 296–310, Jun. 2025. doi: 10.1108/IJILT-10-2024-0240

[27] Z. Dong, "Exploring cross-cultural communication content adaptability through advanced natural language processing and sentiment analysis," *Systems and Soft Computing*, vol. 7, 200290, Dec. 2025. doi: 10.1016/j.sasc.2025.200290

[28] H. Zhang, "Using thermal infrared image processing technology of computer vision to protect art and cultural heritage," *J. Radiat. Res. Appl. Sci.*, vol. 18, no. 4, 101934, Dec. 2025. doi: 10.1016/j.jrras.2025.101934

[29] J. Park and S. Choo, "Generative AI prompt engineering for educators: Practical strategies," *Journal of Special Education Technology*, vol. 40, no. 3, pp. 411–417, Sep. 2025. doi: 10.1177/01626434241298954

[30] L. A. Awang, F. D. Yusop, and M. Danaee, "Insights on usability testing: The effectiveness of an adaptive e-learning system for secondary school mathematics," *International Electronic Journal of Mathematics Education*, vol. 19, no. 3, em0782, Jul. 2024. doi: 10.29333/iejme/14621

[31] T. Wulandari, A. Widiastuti, N. Nasiwan, J. Setiawan, M. R. Fadli, and H. Hadisaputra, "Development of learning models for inculcating Pancasila values," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 12, no. 3, 1364, Sep. 2023. doi: 10.11591/ijere.v12i3.25687

[32] M. I. Ardana, W. I. P. Ariawan, and G. A. D. Sugiharni, "The expansion of sociocultural theory-oriented mathematical learning model," *Cypriot Journal of Educational Sciences*, vol. 16, no. 6, pp. 3016–3032, Dec. 2021. doi: 10.18844/cjes.v16i6.6493

[33] X. Feng, H. Du, J. Ma, H. Wang, L. Zhou, and M. Wang, "Crafting user-centric prompts for UI generations based on Kansei engineering and knowledge graph," *Advanced Engineering Informatics*, vol. 65, 103217, May 2025. doi: 10.1016/j.aei.2025.103217

[34] H. W. Alomari, V. Ramasamy, J. D. Kiper, and G. Potvin, "A User Interface (UI) and User Experience (UX) evaluation framework for cyberlearning environments in computer science and software engineering education," *Heliyon*, vol. 6, no. 5, e03917, May 2020. doi: 10.1016/j.heliyon.2020.e03917

[35] C.-C. Liu, H.-J. Wang, and X.-Q. Gu, "From access to mastery: Integrating AI in blended learning for equitable, inclusive, and accessible music theory educations," *Internet High. Educ.*, vol. 66, 101018, Jun. 2025. doi: 10.1016/j.iheduc.2025.101018

[36] S. Pickel-Chevalier and P. S. Yanthy, "Gender, work, tourism and higher education in Bali," *Ann. Tour. Res.*, vol. 100, 103574, May 2023. doi: 10.1016/j.annals.2023.103574

[37] Y. Mayuzumi, "Is meeting the needs of tourists through ethnic tourism sustainable? Focus on Bali, Indonesia," *Asia-Pacific Journal of Regional Science*, vol. 6, no. 1, pp. 423–451, Feb. 2022. doi: 10.1007/s41685-021-00198-4

[38] B. Hussain, S. Aslam, and A. Imran, "Manufacturing beauty: How AI and social media are redefining aesthetic norms in emerging digital cultures," *Acta Psychol. (Amst).*, vol. 260, 105734, Oct. 2025. doi: 10.1016/j.actpsy.2025.105734

[39] O. H. Salah and M. M. Ayyash, "E-commerce adoption by SMEs and its effect on marketing performance: An extended of TOE framework with ai integration, innovation culture, and customer tech-savviness," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 10, no. 1, 100183, Mar. 2024. doi: 10.1016/j.joitmc.2023.100183

[40] M. González-Delgado, M. Ferraz-Lorenzo, and C. Machado-Trujillo, "Towards an educational modernization process: UNESCO interactions with Franco's Spain (1952–1970)," *History of Education Review*, vol. 51, no. 1, pp. 16–31, Jun. 2022. doi: 10.1108/HER-09-2020-0052

[41] L. Hole, "Handle with care; considerations of Braun and Clarke's approach to thematic analysis," *Qualitative Research Journal*, vol. 24, no. 4, pp. 371–383, Jun. 2024. doi: 10.1108/QRJ-08-2023-0132

[42] H. Yang, "Harnessing generative AI: Exploring its impact on cognitive engagement, emotional engagement, learning retention, reward sensitivity, and motivation through reinforcement theory," *Learn. Motiv.*, vol. 90, 102136, May 2025. doi: 10.1016/j.lmot.2025.102136