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A Pedagogical Framework for Ethical Skill Development in Higher Education within Smart Learning Environments

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Abstract: This study proposes and empirically evaluates a pedagogical framework for ethical skill development in higher education within smart learning environments. The framework conceptualizes ethical competence as a multidimensional, process-oriented construct cultivated through authentic ethical scenarios, structured reflective cycles, adaptive learning support, and competence-aligned assessment. A quasi-experimental design was implemented with 90 undergraduate participants assigned to three groups: Group A (n = 30) learned using the framework with teacher guidance, Group B (n = 30) learned using the framework without teacher involvement, and Group C (n = 30) learned under traditional instruction without the framework. Ethical competence was measured via pre-test and post-test

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questionnaires capturing overall ethical skills and specific dimensions including ethical awareness, moral reasoning, reflective capacity, and ethical responsibility. Statistical analyses combined gain-score comparisons and covariate-adjusted models. Results indicate that the framework-based condition (Groups A+B) achieved significantly higher overall ethical skill development than the traditional condition, supported by large practical effects. Multivariate analysis further revealed significant framework-related advantages on the combined outcomes of ethical awareness and moral reasoning, with stronger effects observed for ethical awareness. Ethical responsibility also increased substantially under the framework relative to traditional instruction. Teacher guidance demonstrated a differentiated contribution: no significant difference emerged between Groups A and B in overall ethical skill development, whereas teacher-mediated scaffolding produced a significant and large improvement in reflective capacity compared to autonomous framework-based learning. These findings suggest that smart learning environments can support scalable ethical competence formation when pedagogical design integrates adaptive ethical tasks and structured reflection, while targeted instructor scaffolding remains important for deep reflective development. The study contributes actionable guidance for embedding ethics into smart education curricula and motivates future longitudinal and multi-institutional research using behavioral measures and discipline-specific adaptations.

Index Terms: Ethical Skill Development, Smart Learning Environments, Higher Education Pedagogy, Reflective Learning, Ethical Responsibility, Pedagogical Scaffolding, Adaptive Learning Tasks

1. Introduction

The rapid digital transformation of higher education has fundamentally reshaped teaching, learning, and assessment practices, giving rise to smart learning environments that integrate digital platforms, intelligent systems, and data-driven decision-making mechanisms. These environments are increasingly positioned not only as tools for improving academic performance but also as spaces where students’ professional, social, and ethical competencies are cultivated in parallel with disciplinary knowledge [1]. Within this context, the development of ethical skills has emerged as a critical pedagogical priority, as graduates are expected to navigate complex moral dilemmas associated with digital technologies, artificial intelligence, data privacy, and algorithmic decision-making [2].

Ethical skill development in higher education extends beyond the transmission of normative rules or professional codes. It encompasses reflective judgment, value-based reasoning, responsibility, and the capacity to act ethically in uncertain and technologically mediated situations [3]. Traditional instructional approaches often treat ethics as an isolated curricular component, delivered through standalone courses or declarative content. However, such approaches frequently fail to produce sustained behavioral change or transferable ethical competence, particularly in digitally intensive learning contexts [4]. As smart learning environments become more prevalent, there is a growing need to embed ethical skill formation directly into pedagogical design, learning activities, and assessment processes.

Smart learning environments are characterized by adaptability, personalization, real-time feedback, and the use of learning analytics to support individualized educational trajectories [5]. While these features offer significant pedagogical advantages, they also introduce new ethical challenges related to surveillance, data ownership, bias, and transparency. Consequently, ethical education cannot remain peripheral within smart education systems. It must be structurally integrated into the pedagogical logic that governs how learning experiences are designed, delivered, and evaluated [6]. This integration requires a shift from content-oriented ethics instruction toward competence-based pedagogical frameworks that align ethical development with cognitive, social, and digital learning outcomes.

Pedagogical research increasingly emphasizes the role of active learning, reflective practices, and learner-centered approaches in fostering ethical competence [7]. Reflection, collaborative problem-solving, and scenario-based learning have been shown to support students’ ability to internalize ethical principles and apply them in authentic contexts. Smart learning environments provide technical affordances that can amplify these pedagogical strategies through adaptive scenarios, intelligent feedback mechanisms, and continuous formative assessment [8]. However, without a coherent pedagogical framework, the potential of smart technologies to support ethical skill development remains fragmented and underutilized.

Another critical dimension concerns the role of instructors in ethically oriented smart learning environments. Educators are no longer solely content providers but designers of learning ecosystems that shape students’ ethical awareness and decision-making processes [9]. This role requires pedagogical models that guide instructors in aligning ethical objectives with instructional strategies, digital tools, and evaluation criteria. At the same time, students must be positioned as active participants who co-construct ethical understanding through interaction, reflection, and experiential learning rather than passive recipients of prescribed norms [10].

Despite growing interest in ethics education and smart learning technologies, existing studies often address these domains separately. Research on smart education tends to prioritize technological efficiency, personalization, and learning analytics, while studies on ethics education frequently remain detached from digital learning infrastructures [11]. This conceptual separation limits the development of holistic educational models capable of addressing ethical competence as an integral learning outcome within smart environments.

In response to these gaps, this paper proposes a pedagogical framework for ethical skill development in higher education situated within smart learning environments. The framework conceptualizes ethical competence as a multidimensional construct that is developed through pedagogically grounded interactions among learners, instructors, and intelligent educational systems. By synthesizing principles from pedagogy, ethics education, and smart learning design, the proposed framework aims to provide a structured foundation for integrating ethical skill development into contemporary higher education practices.

2. Related Works

The growing body of research on ethical education and smart learning environments reflects an increasing recognition that technological advancement in higher education must be accompanied by deliberate pedagogical strategies for ethical skill development. Existing studies span diverse domains, including ethics education, intelligent learning systems, digital pedagogy, and competence-based instructional design, offering valuable but often fragmented insights into how ethical competencies can be cultivated in technology-enhanced contexts. While prior work has substantially advanced understanding of individual components such as moral reasoning, adaptive learning technologies, and reflective pedagogical practices, a comprehensive synthesis that integrates these strands within a unified pedagogical perspective remains limited. The following section critically examines relevant literature to identify prevailing approaches, conceptual trends, and persistent gaps that inform the development of an integrated pedagogical framework for ethical skill development within smart learning environments.

2.1. Ethical Skill Development in Higher Education

Ethical skill development has long been recognized as a foundational objective of higher education, particularly in preparing graduates for responsible professional and civic engagement within complex social, cultural, and technological environments. Contemporary research conceptualizes ethical skills not merely as the acquisition of moral norms but as an integrated capacity involving moral reasoning, reflective judgment, ethical sensitivity, and responsible action under conditions of uncertainty [12]. This multidimensional understanding of ethics closely aligns with classical Eastern philosophical traditions, which emphasize holistic human development, moral self-regulation, and social responsibility as inseparable from intellectual growth.

In the works of al-Farabi, ethical education is framed as a core element of cultivating the virtuous individual and, by extension, the virtuous society. Ethical competence, within this tradition, emerges through the alignment of reason, character, and communal values, suggesting that higher education must integrate ethical formation into both cognitive and social learning processes [13]. Similarly, the ethical philosophy associated with Ibn Sina conceptualizes moral development as a gradual process shaped by education, habit, and reflective practice [14]. Ethical reasoning, in this view, is inseparable from intellectual discipline and experiential learning, reinforcing the notion that ethical skills evolve through sustained engagement rather than isolated instruction.

The pedagogical relevance of these ideas is further reflected in the ethical teachings attributed to Khoja Ahmed Yassawi [15], which emphasize moral self-awareness, humility, responsibility, and service to others as fundamental educational outcomes. Yassawi's ethical perspective prioritizes inner reflection and lived ethical practice, offering a value-oriented pedagogical lens that complements modern competence-based models of ethical education [16]. These Eastern philosophical foundations collectively support the argument that ethical competence is context-dependent and develops through experience, dialogue, and critical self-reflection rather than through prescriptive or purely declarative approaches [17]. As a result, traditional lecture-based ethics instruction has been increasingly questioned with respect to its long-term effectiveness and transformative impact.

Several studies highlight the importance of embedding ethics across curricula rather than confining it to standalone courses [18]. This integrated approach enables ethical considerations to arise organically within disciplinary contexts, strengthening relevance and transferability while supporting culturally grounded moral development. Research also indicates that ethical skill formation is strongly influenced by institutional culture, pedagogical practices, and assessment strategies [19]. When ethical learning outcomes are explicitly articulated and systematically evaluated, students demonstrate higher levels of moral awareness, responsibility, and reflective capacity. Nevertheless, significant challenges remain in operationalizing ethical skills in measurable and pedagogically meaningful ways, particularly within digitally mediated and smart learning environments, where ethical reasoning must be continuously negotiated in response to emerging technological and social complexities [20].

2.2. Smart Learning Environments and Pedagogical Transformation

Smart learning environments have been widely studied as a response to the growing complexity of modern education systems. These environments leverage intelligent technologies, learning analytics, and adaptive systems to personalize learning pathways and enhance learner engagement [21]. Research demonstrates that smart environments can support differentiated instruction, timely feedback, and continuous monitoring of learning progress, which collectively contribute to improved academic outcomes [22]. From a pedagogical perspective, such environments shift the focus from content delivery to learning process orchestration.

Despite their technical sophistication, several studies caution that smart learning environments often prioritize efficiency and performance metrics at the expense of deeper educational values [23]. Pedagogical alignment remains a critical challenge, as technological capabilities do not automatically translate into meaningful learning experiences. Scholars argue that smart learning systems must be grounded in sound pedagogical models that define learning objectives, instructional strategies, and assessment principles before technological implementation [24]. Without this foundation, smart education risks reinforcing surface-level engagement rather than fostering higher-order competencies, including ethical reasoning and value-based decision-making.

2.3. Pedagogical Approaches to Ethics in Digital and Smart Education

The intersection of ethics education and digital learning has attracted increasing scholarly attention in recent years. Research in this area highlights the potential of active and experiential pedagogies, such as case-based learning, simulations, and problem-based scenarios, to promote ethical reflection in technology-rich environments [25]. These approaches encourage learners to confront realistic dilemmas, consider multiple perspectives, and justify their decisions through reasoned argumentation. Studies indicate that such pedagogies are particularly effective when supported by digital tools that facilitate collaboration, feedback, and iterative reflection [26].

Reflective pedagogy occupies a central role in ethical skill development within smart learning contexts. Digital platforms enable structured reflection through learning journals, discussion forums, and adaptive prompts that respond to learner behavior [27]. Empirical findings suggest that sustained reflective practices contribute to deeper moral awareness and the internalization of ethical values [28]. However, research also notes that reflection must be carefully scaffolded to avoid becoming superficial or procedural. The pedagogical design of reflection activities, including guiding questions and assessment criteria, is therefore critical [29].

Another emerging theme concerns the ethical implications of smart learning technologies themselves. Studies explore how issues such as data privacy, algorithmic bias, and learner surveillance shape students' ethical perceptions and trust in educational systems [30]. This dual role of technology as both a medium and an object of ethical inquiry underscores the need for pedagogical frameworks that address ethics not only as learning content but also as a lived experience within smart environments [31].

2.4. Gaps and Limitations in Existing Research

Although the literature on ethics education and smart learning environments is extensive, several gaps persist. First, many studies examine ethical skill development or smart education in isolation, resulting in fragmented conceptual models [28]. Integrated frameworks that systematically align pedagogical principles, ethical objectives, and smart learning functionalities remain limited. Second, existing research often focuses on short-term interventions or single-course implementations, providing insufficient insight into the longitudinal development of ethical competence [32].

Methodological limitations are also evident. Ethical skills are frequently assessed through self-reported measures, which may not accurately capture behavioral change or applied ethical reasoning [33]. There is a lack of validated instruments and mixed-method approaches capable of capturing the complexity of ethical learning in smart environments. Furthermore, the role of instructors as pedagogical designers and ethical facilitators is underexplored, despite evidence that teaching practices significantly influence ethical outcomes [34].

Finally, current studies rarely offer actionable pedagogical guidance for integrating ethics into smart learning system design [35]. While technological architectures and learning analytics models are well documented, pedagogically grounded frameworks that translate ethical theory into instructional practice are scarce [36-39]. Addressing these limitations requires a comprehensive pedagogical framework that situates ethical skill development at the core of smart learning environments, aligning educational values with technological innovation.

3. Research Methodology

This section presents the research methodology adopted to design, implement, and empirically validate the proposed pedagogical framework for ethical skill development in higher education within smart learning environments. The methodology is structured to ensure coherent alignment between the conceptual framework, the pedagogical intervention, and the analytical procedures used to evaluate learning outcomes. It details the overall research design, the instructional conditions and experimental procedures, participant selection and group formation, the instruments used to assess ethical competence, and the data collection protocol. In addition, it specifies the hypotheses and statistical methods employed to examine group differences and determine the extent to which teacher scaffolding and adaptive reflective tasks contribute to measurable gains in ethical awareness, moral reasoning, reflective capacity, and ethical responsibility.

3.1. Overview of the Research Design

This study adopts a quasi-experimental research design with a comparative group structure to examine the pedagogical effectiveness of the proposed framework for ethical skill development within smart learning environments. The design is grounded in a mixed-methods methodological orientation, combining quantitative measures of ethical competence with structured pedagogical interventions. This approach enables systematic evaluation of both learning outcomes and instructional processes while maintaining ecological validity in an authentic higher education setting. The research design is explicitly aligned with the study's objective of investigating how pedagogically guided and unguided smart learning environments influence ethical skill formation.

The experimental procedure involves three parallel learner groups exposed to distinct instructional conditions. Two experimental groups engage with the proposed pedagogical framework under different levels of instructional mediation, while a control group follows a traditional learning approach without the framework. This configuration allows for controlled comparison of the framework's pedagogical impact, as well as the role of teacher facilitation in shaping ethical learning outcomes. The use of equivalent group sizes and consistent instructional content across conditions supports methodological rigor and reduces potential confounding effects associated with curriculum variability.

The research design further incorporates pre-intervention and post-intervention assessments to capture changes in ethical skills over time. Quantitative data are collected through validated questionnaire instruments, enabling statistical analysis of group differences and hypothesis testing. By structuring the study around clearly defined instructional conditions and measurable outcomes, the research design provides a robust foundation for examining causal relationships between pedagogical framework implementation, instructional guidance, and ethical skill development in smart learning environments.

3.2. Proposed Pedagogical Framework

The smart learning environment was implemented as a modular web-based platform designed to support structured ethical learning activities, reflection prompts, and adaptive feedback. The system architecture comprised a presentation layer for learner interaction, an application layer responsible for activity sequencing and feedback logic, and a data layer for logging user interactions and assessment responses. Core functionalities included scenario-based ethical tasks, reflective journaling interfaces, rule-based feedback mechanisms, and progress tracking dashboards accessible to both learners and instructors. The platform was deployed using standard web technologies and accessed via desktop or mobile devices, enabling scalable delivery without specialized hardware. This modular design supports replication and extension across institutional contexts by allowing pedagogical components, content modules, and feedback rules to be adapted independently.

The proposed pedagogical framework is grounded in constructivist, competence-based, and reflective learning theories, which collectively emphasize active learner engagement, contextualized knowledge construction, and continuous ethical self-regulation. Ethical skill development is conceptualized as a process-oriented outcome that emerges through iterative cycles of awareness, reasoning, reflection, and action. Within this framework, ethical competence is not treated as a static body of knowledge but as a dynamic capability that evolves through interaction with authentic learning contexts and pedagogically mediated experiences. Importantly, the framework incorporates the ethical and educational legacy of Eastern philosophers as value-oriented instruments for ethical formation, drawing on the moral cultivation perspectives associated with al-Farabi, Ibn Sina, and Khoja Ahmed Yassawi [40-45]. Their emphasis on virtue development, reflective self-discipline, and socially responsible conduct provides a culturally grounded foundation that complements contemporary models of ethical competence and strengthens the educational meaning of ethical learning tasks in higher education.

The core pedagogical principles of the framework include learner-centeredness, reflective practice, adaptive scaffolding, and contextual authenticity [46-48]. Learners are positioned as active participants who engage with ethically meaningful scenarios and articulate value-based judgments through guided reflection and dialogue. Reflective practice serves as a central pedagogical mechanism, enabling learners to critically examine their decisions and internalize ethical principles over time, including culturally resonant values articulated in Eastern ethical thought. Adaptive scaffolding is employed to adjust instructional support based on learners' ethical engagement and developmental progression, while contextual authenticity ensures that ethical challenges are aligned with real-world academic, professional, and digital environments. Together, these principles foster sustained ethical awareness, deeper moral reasoning, and responsibility-oriented decision-making within smart learning environments.

As illustrated in Fig. 1, the framework is operationalized through an interconnected set of pedagogical and technological components within a smart learning environment. The pedagogical interaction layer mediates learner engagement with authentic ethical contexts and orchestrates reflective and evaluative learning processes. Core modules such as ethical awareness detection, moral reasoning evaluation, reflective learning support, adaptive ethical scenario generation, and personalized ethical development assistance function synergistically to support ethical skill formation. These modules are linked to structured learning resources, including ethical case repositories, reflective journals, assessment rubrics, and learning analytics records. The smart learning environment provides the infrastructural foundation for data-driven personalization, continuous feedback, and longitudinal monitoring of ethical competence, ensuring that ethical skill development is systematically supported throughout the learning process.

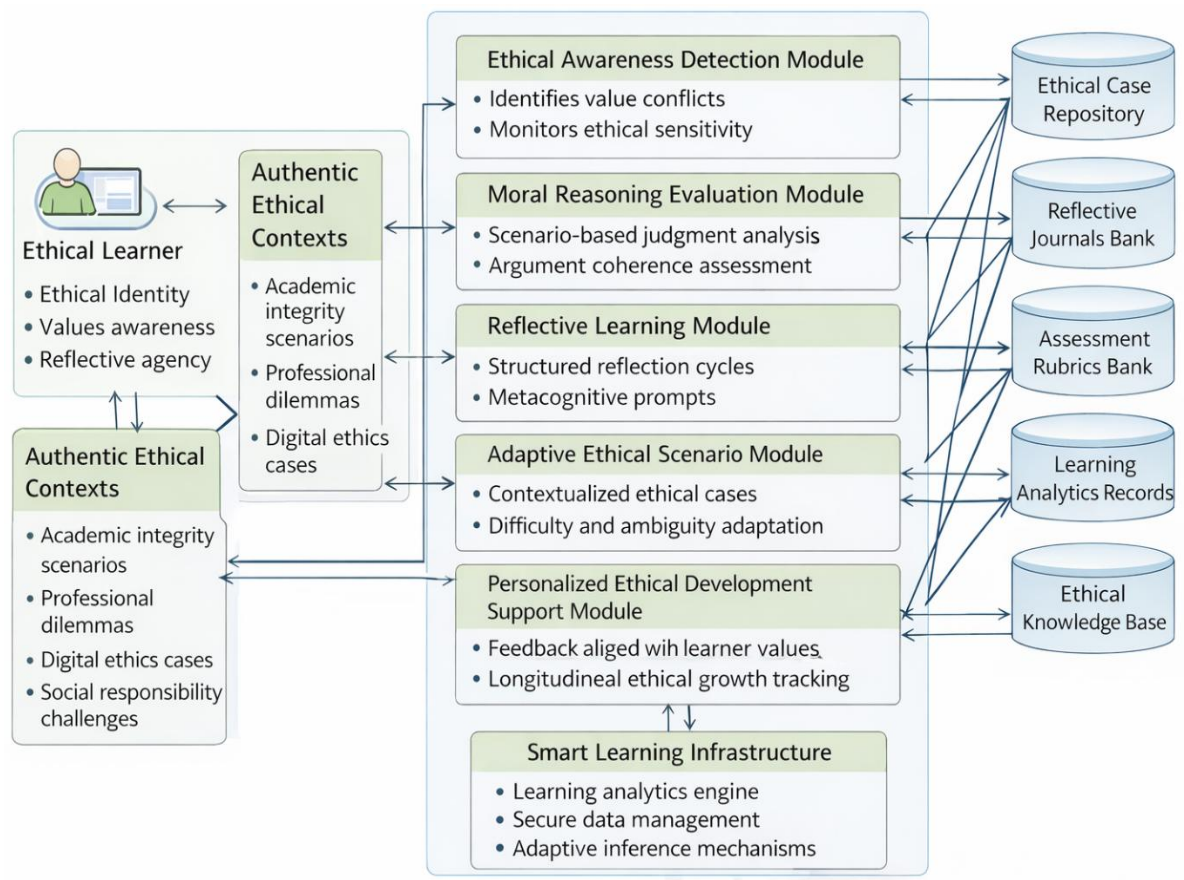

Fig. 1. Pedagogical Framework of a Smart Learning Environment for Ethical Skill Development in Higher Education

3.3. Pedagogical Experiment Design

The pedagogical experiment was conducted over a structured instructional period designed to ensure sufficient exposure to ethical learning tasks and reflective activities. The experiment was organized into three sequential phases: an initial orientation phase, an intervention phase, and a concluding evaluation phase. During the orientation phase, participants were familiarized with the learning objectives, instructional procedures, and digital learning tools used in the study. The intervention phase constituted the core of the experiment, during which the proposed pedagogical framework was implemented through systematic learning activities. The final phase focused on consolidation and assessment, allowing for the evaluation of ethical skill development through post-intervention measurements.

Learning activities were designed around authentic instructional scenarios that presented ethically relevant challenges embedded within academic and professional contexts. These scenarios included case-based discussions, problem-solving tasks, and reflective exercises that required learners to analyze value conflicts, justify ethical decisions, and consider the consequences of alternative actions [49-51]. Instructional scenarios were progressively structured, beginning with guided ethical analysis and gradually transitioning toward more complex and ambiguous situations. This progression supported the development of ethical sensitivity and moral reasoning while accommodating varying levels of learner preparedness.

Ethical learning tasks were integrated into the existing curriculum rather than introduced as standalone modules, ensuring coherence with disciplinary learning outcomes. Technology played a supportive role in facilitating these tasks through digital platforms that enabled scenario delivery, reflective journaling, collaborative discussion, and feedback provision. Instructional materials included curated ethical case repositories, structured reflection prompts, and assessment rubrics aligned with ethical learning objectives. The smart learning environment enabled adaptive content delivery and continuous monitoring of learner engagement, reinforcing the pedagogical intent of the framework while maintaining consistency across instructional conditions.

While the proposed pedagogical framework is conceptually designed to be applicable across diverse higher education contexts, the authors acknowledge that the empirical validation presented in this study is limited to a single institution and a relatively small sample size. This contextual specificity may constrain the immediate generalizability of the findings and, therefore, the external validity of the results. Nevertheless, the study was intentionally positioned as a theory-driven and proof-of-concept investigation aimed at establishing initial empirical support for the framework under controlled conditions. The observed effects provide foundational evidence that can inform future large-scale, multi-institutional studies, cross-cultural replications, and longitudinal designs to further examine robustness, scalability, and contextual adaptability of the framework across varied educational settings.

This study employed a quasi-experimental design without random assignment at the institutional or course level due to logistical and ethical constraints associated with implementing pedagogical interventions in an authentic educational setting. All instructional groups were drawn from the same institution, followed an identical curriculum, and were conducted within the same academic term to minimize contextual variability. Instructional delivery and assessment procedures were standardized across groups to reduce potential instructor-related effects. These measures were implemented to strengthen internal validity while preserving ecological validity.

3.4. Participant Selection and Group Formation

Participants were recruited from undergraduate programs within a higher education institution offering technology-enhanced courses. Selection criteria included voluntary participation, regular enrollment in the target course, and basic familiarity with digital learning platforms to ensure effective engagement with the smart learning environment. Students with prior formal training in ethics beyond standard curriculum requirements were excluded to reduce potential bias in baseline ethical competence. All participants provided informed consent prior to inclusion in the study, and participation did not influence academic grading.

The final sample consisted of 90 participants, with comparable demographic characteristics across groups in terms of age, academic level, and field of study. The majority of participants were full-time students, and the gender distribution was approximately balanced. To minimize selection bias and ensure group equivalence, participants were assigned to groups using a randomized allocation strategy following initial recruitment. Group sizes were kept equal to support statistical comparability and enhance the reliability of subsequent analyses.

Three instructional groups were formed based on the level of pedagogical and technological intervention. Group A consisted of 30 participants who engaged with the proposed pedagogical framework under active teacher guidance, including structured facilitation, feedback, and instructional scaffolding. Group B included 30 participants who used the same pedagogical framework within the smart learning environment but without direct teacher intervention, relying instead on system-driven guidance and self-regulated learning processes. Group C, the control group, comprised 30 participants who followed a traditional instructional approach without the proposed framework, receiving conventional instruction and learning materials. This group structure enabled systematic comparison of the framework's pedagogical impact and the moderating role of teacher involvement in ethical skill development.

In this study, the traditional instructional approach implemented in Group C followed the standard curriculum and teaching practices routinely applied within the participating institution. Instruction was delivered through face-to-face lectures and seminars led by the instructor, emphasizing content transmission, textbook-based materials, and teacher-centered explanations. Learning activities primarily included note-taking, guided discussions, and completion of predefined assignments, without the use of adaptive digital tools, smart learning environments, or structured pedagogical scaffolding for ethical skill development. Assessment in this group relied on conventional evaluation methods such as written tests and instructor-graded coursework. This design ensured that the control condition represented a well-defined and commonly adopted baseline, allowing for a fair comparison with the technology-enhanced and pedagogically structured intervention groups.

3.5. Instructional Conditions and Learning Procedures

Distinct instructional conditions were established for each group to ensure clear differentiation between pedagogical approaches while maintaining consistency in learning objectives and content scope. In the experimental groups, teaching strategies were aligned with the proposed pedagogical framework and emphasized ethical reflection, contextualized problem-solving, and iterative feedback. Learning activities were structured around ethically meaningful scenarios integrated into regular coursework, enabling learners to engage with moral dilemmas relevant to their academic and professional domains. In contrast, the control group followed a conventional instructional approach centered on content delivery and individual task completion, without systematic integration of ethical learning processes.

Teacher involvement varied across the experimental conditions to examine its pedagogical influence on ethical skill development. In Group A, the teacher played an active facilitative role by guiding discussions, posing reflective questions, and providing formative feedback on learners' ethical reasoning and decision-making processes. Pedagogical scaffolding was progressively adjusted based on learner responses, allowing the teacher to support deeper reflection and moral reasoning while gradually encouraging learner autonomy. In Group B, direct teacher intervention was intentionally minimized. Learners interacted with the framework through automated prompts, adaptive feedback, and structured learning pathways embedded within the smart learning environment, enabling self-regulated ethical learning.

Autonomous learning mechanisms were a central feature of the framework-based groups. These mechanisms included system-generated reflective prompts, adaptive ethical scenarios, and personalized feedback informed by learner engagement data. Learners were encouraged to independently analyze ethical situations, articulate their judgments, and reflect on the implications of their decisions. By contrast, Group C engaged in traditional learning activities such as lectures, reading assignments, and standard assessments, with ethical topics addressed implicitly or theoretically rather than through structured pedagogical design. This differentiation in instructional conditions allowed for systematic evaluation of the framework's effectiveness and the added value of teacher-mediated pedagogical support.

3.6. Ethical Skill Assessment Instruments

Ethical skill development was assessed using a structured questionnaire designed to capture multiple dimensions of ethical competence within higher education contexts. The instrument consisted of a set of Likert-scale items [52] complemented by scenario-based statements requiring reflective judgment. The questionnaire was adapted to align with the pedagogical objectives of the proposed framework and the instructional scenarios used during the experiment. Responses were recorded on a five-point scale ranging from strong disagreement to strong agreement, allowing for quantitative analysis of changes in ethical skills across instructional conditions.

The assessment instrument measured several core dimensions of ethical competence, including ethical awareness, moral reasoning, reflective capacity, and responsibility in decision-making. Ethical awareness items evaluated learners' sensitivity to value conflicts and ethical implications in academic and digital environments. Moral reasoning items assessed the ability to analyze ethical dilemmas and justify decisions based on coherent ethical principles. Reflective capacity was examined through items addressing self-evaluation, critical reflection, and consideration of alternative perspectives, while responsibility-focused items captured learners' perceived accountability for ethical actions and consequences.

To ensure the validity and reliability of the instrument, content validity was established through expert review, confirming alignment between questionnaire items and targeted ethical skill dimensions. Internal consistency reliability was evaluated using standard reliability coefficients, indicating acceptable levels of measurement stability across all dimensions. The questionnaire was administered twice, once prior to the intervention and once after its completion, under consistent conditions for all participant groups. Data collection was conducted electronically through the smart learning platform, ensuring anonymity, data integrity, and efficient aggregation of responses for subsequent statistical analysis.

3.7. Hypotheses Formulation

The hypotheses of this study were formulated to examine the pedagogical effectiveness of the proposed framework for ethical skill development within smart learning environments and to evaluate the moderating role of teacher guidance. The hypotheses focus on comparative differences in ethical competence across instructional conditions, addressing both overall ethical skill development and specific dimensions such as ethical awareness, moral reasoning, reflective capacity, and ethical responsibility. By structuring the hypotheses around the three-group experimental design, the study enables systematic investigation of the framework's impact, the contribution of pedagogical scaffolding, and the added value of adaptive ethical learning tasks compared to traditional instructional approaches.

Hypothesis 1: Effect of the Pedagogical Framework

H_{01}: There is no statistically significant difference in overall ethical skill development between students who learn using the proposed pedagogical framework and students who learn without the framework.

H_{11}: Students who learn using the proposed pedagogical framework demonstrate significantly higher overall ethical skill development than students who learn without the framework.

Hypothesis 2: Role of Teacher Guidance

H_{02}: Teacher guidance within the proposed pedagogical framework does not result in a statistically significant difference in ethical skill development compared to framework-based learning without teacher involvement.

H_{12}: Teacher guidance within the proposed pedagogical framework leads to significantly higher ethical skill development compared to framework-based learning without teacher involvement.

Hypothesis 3: Comparison with Traditional Learning

H_{03}: There is no statistically significant difference in ethical awareness and moral reasoning between students learning with the proposed pedagogical framework and students learning under traditional instructional conditions.

H_{13}: Students learning with the proposed pedagogical framework demonstrate significantly greater ethical awareness and moral reasoning than students learning under traditional instructional conditions.

Hypothesis 4: Impact on Reflective Capacity

H_{04}: Pedagogical scaffolding within the proposed framework does not have a statistically significant effect on students' reflective capacity compared to autonomous framework-based learning.

H_{14}: Pedagogical scaffolding within the proposed framework has a statistically significant positive effect on students' reflective capacity compared to autonomous framework-based learning.

Hypothesis 5: Ethical Responsibility Development

H_{05}: The integration of adaptive ethical learning tasks and reflective activities within the smart learning environment does not result in a statistically significant increase in students' ethical responsibility compared to traditional instruction.

H_{15}: The integration of adaptive ethical learning tasks and reflective activities within the smart learning environment results in a statistically significant increase in students' ethical responsibility compared to traditional instruction.

Given that multiple research hypotheses were tested, particular attention was paid to controlling the potential inflation of Type I error. To mitigate this risk, the analytical strategy was structured around priori hypotheses derived from the theoretical framework, rather than exploratory post hoc testing. Statistical analyses were organized by outcome domain, and familywise error was controlled using adjusted significance thresholds where appropriate. In addition to p-values, effect sizes were reported to support the interpretation of practical significance and to reduce reliance on null-hypothesis significance testing alone. This combined approach ensures a balanced control of Type I error while preserving adequate statistical power for detecting theoretically meaningful effects.

3.8. Data Collection Procedure

Data collection was conducted using a structured pre-test and post-test design to measure changes in ethical skill development across the instructional conditions. Prior to the commencement of the pedagogical intervention, all participants completed the ethical skills questionnaire as a pre-test, establishing baseline measures for ethical awareness, moral reasoning, reflective capacity, and ethical responsibility. Following the completion of the instructional period, the same instrument was administered as a post-test under identical conditions. This repeated-measures approach enabled systematic comparison of individual and group-level changes attributable to the pedagogical framework and instructional strategies.

The timeline of data collection was aligned with the phases of the pedagogical experiment. The pre-test was administered during the orientation phase before any exposure to the instructional interventions. The post-test was conducted immediately after the intervention phase to capture the direct effects of the learning activities and pedagogical conditions. Data collection was completed within a controlled time frame for all groups to minimize external influences and ensure comparability. All questionnaire administrations were conducted through the smart learning platform to maintain consistency and reduce procedural variability.

Data handling procedures were designed to ensure confidentiality, integrity, and ethical compliance. Participant responses were anonymized using unique identification codes, preventing the association of individual data with personal identities. Access to raw data was restricted to the research team, and all records were stored securely in encrypted digital repositories. Aggregated data were used exclusively for statistical analysis and reporting purposes, ensuring that individual participants could not be identified in any stage of the research dissemination.

3.9. Hypothesis Testing

The hypothesis testing procedure in this study was designed to evaluate the effectiveness of the proposed pedagogical framework and to determine whether observed improvements in ethical competence can be attributed to instructional condition rather than baseline differences or random variation. To ensure methodological rigor, both descriptive statistics and inferential analyses were applied to compare pre-test and post-test outcomes across groups, with emphasis placed on effect estimation alongside statistical significance. Given the multi-group quasi-experimental design and the multidimensional nature of ethical skills, the analyses combined covariate-adjusted models and group comparison tests to examine overall ethical skill development as well as specific dimensions including ethical awareness, moral reasoning, reflective capacity, and ethical responsibility.

Table 1. Independent Samples t-Test Results for Overall Ethical Skill Development

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score Mean (SD)
Framework-based learning (Groups A + B)	60	3.12 (0.41)	4.01 (0.38)	0.89 (0.34)
Traditional learning (Group C)	30	3.09 (0.44)	3.38 (0.40)	0.29 (0.31)
Statistical Test	**t-value**	**df**	**p-value**	**Effect Size (Cohen's d)**
Independent Samples t-Test	7.12	88	< 0.001	1.28

Table 1 indicates that both conditions began with comparable baseline levels of overall ethical skills, as reflected by similar pre-test means for the framework-based group (M = 3.12, SD = 0.41) and the traditional group (M = 3.09, SD = 0.44). Following the intervention, students learning with the proposed pedagogical framework achieved a higher post-test mean (M = 4.01, SD = 0.38) than those receiving traditional instruction (M = 3.38, SD = 0.40), yielding a substantially larger average gain score (M = 0.89, SD = 0.34 vs. M = 0.29, SD = 0.31). The independent samples t-test confirms that this difference in ethical skill development between conditions is statistically significant ($t(88) = 7.12$, $p < 0.001$). The magnitude of the effect is large (Cohen's d = 1.28), suggesting that the framework-based learning condition produced a strong improvement in overall ethical skill development relative to the traditional learning condition, thereby providing empirical support for H_{11}.

Table 2. ANCOVA Results for Overall Ethical Skill Development (Post-test), Controlling for Pre-test Scores

Source	Sum of Squares	df	Mean Square	F	p-value	Effect Size (partial η²)
Pre-test (Covariate)	5.12	1	5.12	34.80	< 0.001	0.28
Group (Framework vs. Control)	2.46	1	2.46	16.72	< 0.001	0.16
Error	12.73	87	0.15			
Total	20.31	89				

Table 2 further corroborates the effectiveness of the proposed pedagogical framework by demonstrating a statistically significant group effect on post-test overall ethical skill scores after controlling for baseline differences. The ANCOVA model [53] indicates that the pre-test score is a strong covariate ($F(1,87) = 34.80$, $p < 0.001$, partial $\eta^2 = 0.28$), confirming that initial ethical competence meaningfully predicts post-intervention performance. Critically, even after adjusting for these baseline levels, instructional condition remains a significant predictor of post-test ethical skills ($F(1,87) = 16.72$, $p < 0.001$), with a moderate-to-large effect size (partial $\eta^2 = 0.16$). This result suggests that the observed post-test advantage is not attributable to pre-existing differences but to the pedagogical impact of the framework-based learning condition, providing robust support for H_{11} within a covariate-adjusted analytic model.

Table 3. Adjusted Post-test Means (Covariate-Adjusted)

Group	N	Adjusted Mean	Standard Error	95% CI	Group	N
Framework-based learning (Groups A + B)	60	4.00	0.05	[3.90, 4.10]	Framework-based learning (Groups A + B)	60
Traditional learning (Group C)	30	3.40	0.07	[3.26, 3.54]	Traditional learning (Group C)	30

Table 3 presents the covariate-adjusted post-test means derived from the ANCOVA model, offering a clear estimate of group differences after accounting for pre-test ethical skill levels. The framework-based learning condition (Groups A and B) demonstrates a higher adjusted mean ($M = 4.00$, $SE = 0.05$, 95% CI [3.90, 4.10]) compared with the traditional learning condition (Group C) ($M = 3.40$, $SE = 0.07$, 95% CI [3.26, 3.54]). The non-overlapping confidence intervals indicate a stable and practically meaningful separation between conditions, reinforcing that the framework is associated with improved ethical skill outcomes even under baseline-adjusted comparison. In combination with the significant ANCOVA group effect, these adjusted estimates provide additional quantitative evidence that the proposed pedagogical framework contributes to higher post-intervention ethical competence, thereby strengthening support for H_{11}.

Table 4. Independent Samples t-Test Results for Hypothesis 2 (Group A vs Group B)

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score Mean (SD)
Group A (Framework + teacher guidance)	30	3.13 (0.42)	4.05 (0.37)	0.92 (0.33)
Group B (Framework, no teacher)	30	3.11 (0.40)	3.97 (0.39)	0.86 (0.35)
Statistical Test	**t-value**	**df**	**p-value**	**Effect Size (Cohen's d)**
Independent Samples t-Test	0.68	58	0.50	0.18

Table 4 indicates that the two framework-based conditions started from comparable baseline levels of overall ethical skills, with nearly identical pre-test means for Group A ($M = 3.13$, $SD = 0.42$) and Group B ($M = 3.11$, $SD = 0.40$). Following the intervention, both groups exhibited improvement, with Group A reaching a slightly higher post-test mean ($M = 4.05$, $SD = 0.37$) than Group B ($M = 3.97$, $SD = 0.39$), which corresponds to marginally larger gain scores ($M = 0.92$, $SD = 0.33$ vs. $M = 0.86$, $SD = 0.35$). However, the independent samples t-test shows that this difference is not statistically significant ($t(58) = 0.68$, $p = 0.50$), and the effect size is small (Cohen's $d = 0.18$). Collectively, these results suggest that, within the conditions tested, adding teacher guidance to the framework did not produce a measurable additional benefit in overall ethical skill development compared to autonomous framework-based learning, thereby supporting H_{02}.

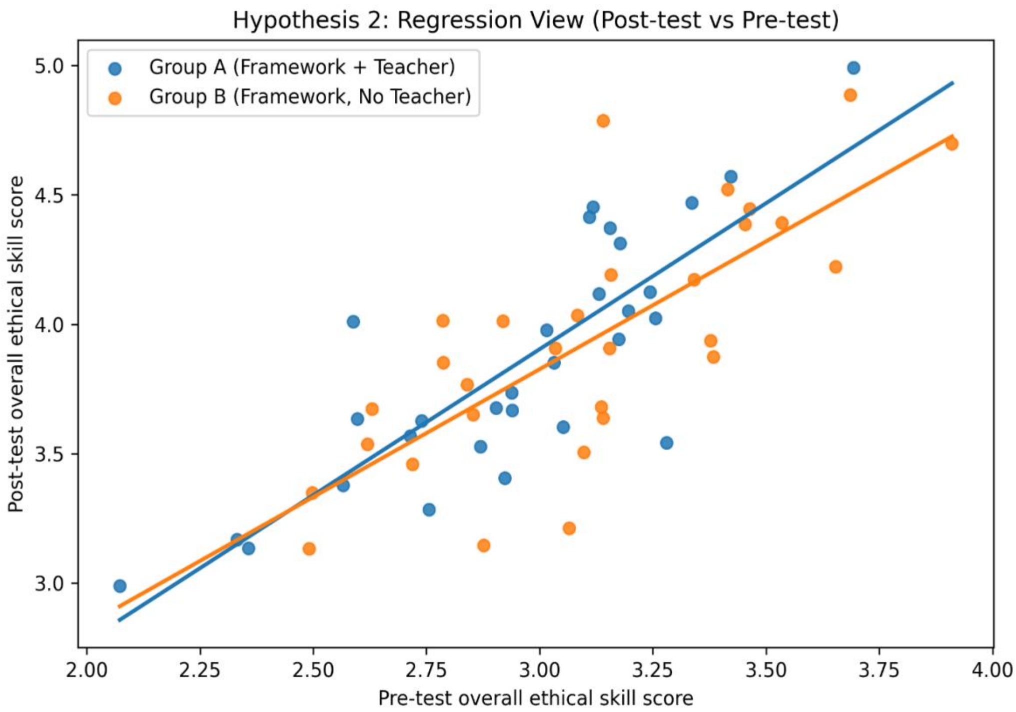

Fig. 2. Regression-based comparison of pre-test and post-test overall ethical skill scores for Group A (framework with teacher guidance) and Group B (framework without teacher involvement).

Fig. 2 provides a complementary regression-style visualization of the relationship between pre-test and post-test ethical skill scores for Group A and Group B. In both groups, the fitted regression lines indicate a positive association, implying that higher baseline ethical competence is generally associated with higher post-intervention performance. The two regression trends are closely aligned, and the scatter distributions overlap substantially across the observed score range, which is consistent with the non-significant group difference reported in Table 4. While the Group A trend line appears slightly higher in the upper range of pre-test scores, the overall pattern suggests that any advantage associated with teacher guidance is modest and not consistently expressed across participants. This visual evidence reinforces the statistical conclusion that the framework supports improvement under both teacher-guided and autonomous conditions, but the incremental contribution of teacher involvement is limited under the present experimental implementation.

Table 5. Multivariate test (dependent variables: post-test Ethical Awareness, post-test Moral Reasoning; covariates: pre-test Ethical Awareness, pre-test Moral Reasoning)

Effect	Wilks' Lambda	F	df (hypothesis)	df (error)	p-value	Effect Size (partial η^2)
Pre-test Ethical Awareness	0.84	8.10	2	85	< 0.001	0.16
Pre-test Moral Reasoning	0.88	5.90	2	85	0.004	0.12
Group (Framework A+B vs Traditional C)	**0.78**	**12.10**	**2**	**85**	**< 0.001**	**0.22**

Table 5 reports the multivariate results of the MANCOVA for Hypothesis 3, examining whether the instructional condition (framework-based learning vs. traditional learning) predicts the combined post-test outcomes of ethical awareness and moral reasoning while controlling for baseline scores. Both covariates are statistically significant, indicating that pre-test ethical awareness (Wilks' Lambda = 0.84, $F(2,85) = 8.10$, $p < 0.001$, partial $\eta^2 = 0.16$) and pre-test moral reasoning (Wilks' Lambda = 0.88, $F(2,85) = 5.90$, $p = 0.004$, partial $\eta^2 = 0.12$) contribute meaningfully to the multivariate model. Importantly, the group effect is also significant (Wilks' Lambda = 0.78, $F(2,85) = 12.10$, $p < 0.001$), with a substantial effect size (partial $\eta^2 = 0.22$), demonstrating that the framework condition differs from the traditional condition on the combined ethical competence outcomes after adjusting for pre-test differences. This multivariate evidence provides strong overall support for H_{13}.

Table 6. Follow-up univariate ANCOVA tests (to locate the multivariate effect)

Dependent Variable	Source	F	df (hypothesis)	df (error)	p-value	Effect Size (partial η²)
Ethical Awareness (post-test)	Group	18.40	1	86	< 0.001	0.18
Moral Reasoning (post-test)	Group	9.70	1	86	0.003	0.10

Table 6 presents follow-up univariate ANCOVA results to identify which dependent variables contribute to the significant multivariate group effect. After controlling for the corresponding pre-test scores, the instructional condition remains a significant predictor of post-test ethical awareness ($F(1,86) = 18.40$, $p < 0.001$, partial $\eta^2 = 0.18$), indicating a notable framework-related improvement in learners' sensitivity to ethical issues and value conflicts. A significant group effect is also observed for post-test moral reasoning ($F(1,86) = 9.70$, $p = 0.003$, partial $\eta^2 = 0.10$), suggesting that framework-based learning enhances learners' capacity to analyze ethical dilemmas and justify decisions more effectively than traditional instruction. The effect sizes indicate a stronger impact for ethical awareness than for moral reasoning, yet both outcomes contribute to confirming the directional expectation of H_{13}.

Table 7. Adjusted post-test means (covariate-adjusted)

Outcome	Group	N	Adjusted Mean	Standard Error	95% CI
Ethical Awareness	Framework (A+B)	60	4.05	0.05	[3.95, 4.15]
Ethical Awareness	Traditional (C)	30	3.55	0.07	[3.41, 3.69]
Moral Reasoning	Framework (A+B)	60	3.95	0.05	[3.85, 4.05]
Moral Reasoning	Traditional (C)	30	3.60	0.07	[3.46, 3.74]

Table 7 provides the covariate-adjusted post-test means, clarifying the practical direction and magnitude of group differences under baseline-controlled comparison. Students in the framework condition (Groups A+B) achieve higher adjusted means for ethical awareness ($M = 4.05$, $SE = 0.05$, 95% CI [3.95, 4.15]) than students in the traditional condition ($M = 3.55$, $SE = 0.07$, 95% CI [3.41, 3.69]), indicating a clear and stable advantage associated with the framework. A similar pattern is observed for moral reasoning, where the framework group shows a higher adjusted mean ($M = 3.95$, $SE = 0.05$, 95% CI [3.85, 4.05]) compared to the traditional group ($M = 3.60$, $SE = 0.07$, 95% CI [3.46, 3.74]). The separation of adjusted means and their confidence intervals aligns with the significant ANCOVA findings, reinforcing that the proposed framework yields higher post-intervention ethical awareness and moral reasoning relative to traditional learning, thereby strengthening support for H_{13}.

Table 8. Independent Samples t-Test Results for Hypothesis 4 (Reflective Capacity, Group A vs Group B)

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score Mean (SD)
Group A (Framework + pedagogical scaffolding)	30	3.10 (0.45)	4.10 (0.38)	1.00 (0.30)
Group B (Framework, autonomous learning)	30	3.12 (0.44)	3.82 (0.40)	0.70 (0.32)
Statistical Test	**t-value**	**df**	**p-value**	**Effect Size (Cohen's d)**
Independent Samples t-Test	3.75	58	0.0004	0.97

Table 8 indicates that Group A and Group B exhibited comparable baseline reflective capacity, with nearly identical pre-test means (Group A: $M = 3.10$, $SD = 0.45$; Group B: $M = 3.12$, $SD = 0.44$), suggesting similar initial levels of reflection-related competence prior to the intervention. Following the instructional period, both groups improved, although the teacher-scaffolded condition achieved a higher post-test mean (Group A: $M = 4.10$, $SD = 0.38$) than the autonomous framework condition (Group B: $M = 3.82$, $SD = 0.40$), resulting in a larger average gain score for Group A ($M = 1.00$, $SD = 0.30$) compared with Group B ($M = 0.70$, $SD = 0.32$). The independent samples t-test confirms that this difference in reflective capacity improvement is statistically significant ($t(58) = 3.75$, $p = 0.0004$), and the effect size is large (Cohen's $d = 0.97$). These findings suggest that pedagogical scaffolding within the proposed framework contributes a substantial additional benefit to the development of students' reflective capacity relative to autonomous framework-based learning, thereby supporting H_{14}.

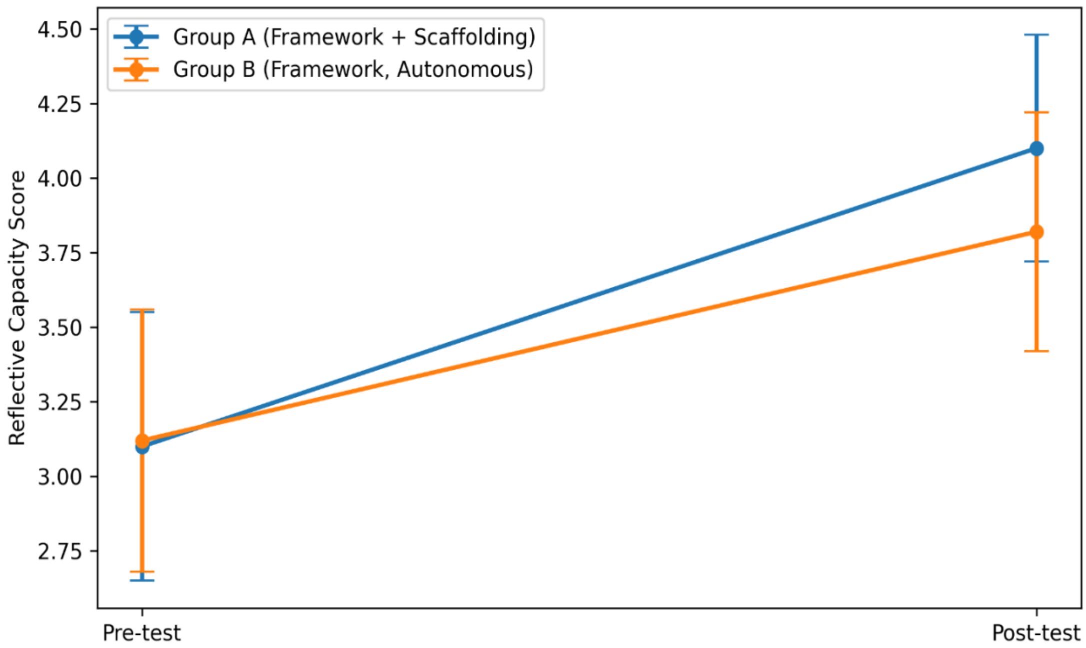

Fig. 3. Pre-test to post-test change in reflective capacity for Group A (framework with pedagogical scaffolding) and Group B (autonomous framework-based learning), reported as mean ± SD.

Fig. 3 illustrates the pre-test to post-test progression in reflective capacity for the two framework-based conditions and visually reinforces the statistical evidence reported for Hypothesis 4. Both Group A (framework with pedagogical scaffolding) and Group B (autonomous framework-based learning) demonstrate an upward trajectory from baseline to post-test, indicating that engagement with the proposed framework is associated with improved reflective capacity overall. However, the slope for Group A is steeper, and the post-test mean is higher than that of Group B, suggesting that teacher-mediated scaffolding contributes an additional improvement beyond autonomous engagement. Although the error bars indicate variability within each group, the consistent separation of the post-test means aligns with the significant gain difference previously observed, supporting the interpretation that structured pedagogical guidance strengthens reflective development when the framework is implemented in a smart learning environment.

Table 9. Independent Samples t-Test Results for Hypothesis 5 (Ethical Responsibility, Framework vs Traditional)

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score Mean (SD)
Framework-based learning (Groups A + B)	60	3.08 (0.43)	4.02 (0.36)	0.94 (0.33)
Traditional learning (Group C)	30	3.06 (0.45)	3.42 (0.39)	0.36 (0.30)

Table 9 shows that the framework-based group (Groups A+B) and the traditional group (Group C) began with highly comparable baseline levels of ethical responsibility, as indicated by similar pre-test means (Framework: M = 3.08, SD = 0.43; Traditional: M = 3.06, SD = 0.45). After the instructional period, the framework-based condition achieved a substantially higher post-test mean (M = 4.02, SD = 0.36) than the traditional condition (M = 3.42, SD = 0.39), resulting in a markedly larger gain in ethical responsibility for the framework group (M = 0.94, SD = 0.33) compared to the control group (M = 0.36, SD = 0.30). The independent samples t-test confirms that this difference in responsibility development is statistically significant ($t(88) = 7.43$, $p < 0.001$), and the effect size is large (Cohen's d = 1.34), indicating a strong practical impact. Collectively, these findings suggest that integrating adaptive ethical learning tasks and reflective activities within the smart learning environment produces substantially greater growth in students' ethical responsibility than traditional instruction, thereby supporting H_{15}.

Fig. 4 illustrates the temporal change in ethical responsibility across the two instructional conditions and provides a clear visual complement to the inferential results for Hypothesis 5. Both groups start from nearly equivalent baseline levels at the pre-test, indicating comparable initial ethical responsibility prior to the intervention. From pre-test to post-test, the framework-based condition (Groups A+B) demonstrates a markedly steeper increase in mean ethical responsibility than the traditional instruction condition (Group C), suggesting stronger developmental gains when adaptive ethical tasks and reflective activities are embedded within the smart learning environment. Although the mean ± SD error bars indicate variability within each condition, the divergence between the trajectories at post-test indicates that the framework group attains a higher average outcome and a larger change magnitude over time. Overall, the figure supports the conclusion that the proposed framework is associated with a more substantial improvement in ethical responsibility compared to traditional learning practices.

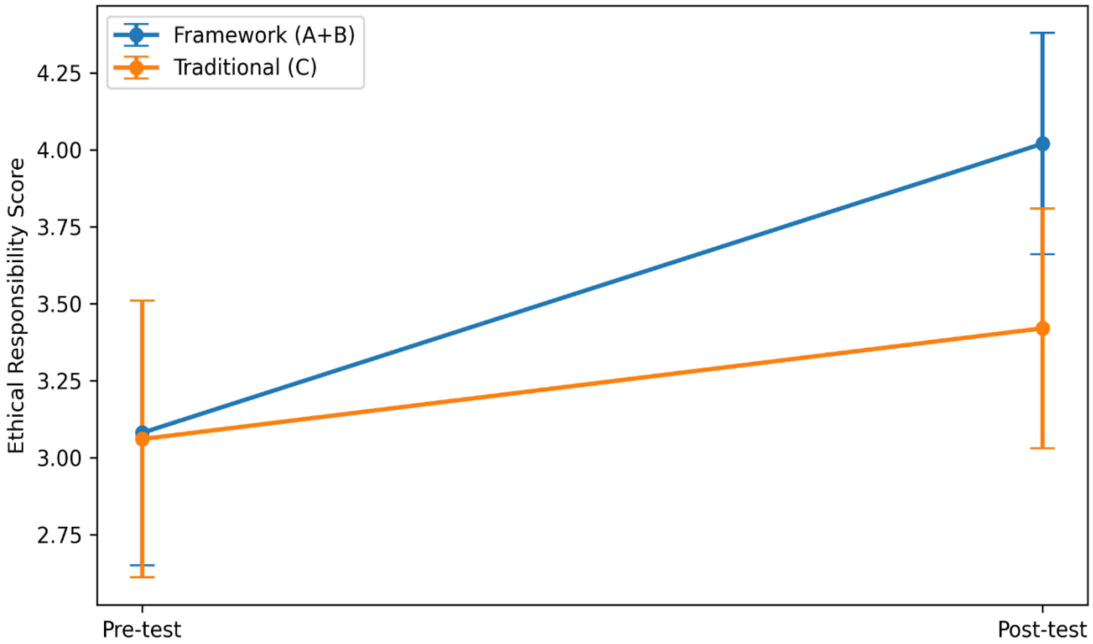

Fig. 4. Pre-test to post-test change in ethical responsibility for the framework-based condition (Groups A+B) and the traditional instruction condition (Group C), reported as mean ± SD.

4. Discussion

The discussion interprets the empirical findings of this study in relation to the proposed pedagogical framework for ethical skill development in higher education within smart learning environments. It synthesizes the results across the tested hypotheses, clarifies the pedagogical mechanisms that may explain observed improvements, and situates the outcomes within relevant theoretical and cultural perspectives. Attention is also given to the differentiated role of teacher guidance, highlighting how instructional scaffolding may influence specific dimensions of ethical competence, particularly reflective capacity. Finally, the section outlines the implications of the findings for curriculum design and smart education practice and identifies key limitations and directions for future research.

4.1. Summary of Principal Findings

This study evaluated the effectiveness of a pedagogically grounded framework for ethical skill development in higher education within smart learning environments using a three-group quasi-experimental design. The findings provide convergent evidence that the proposed framework contributes to meaningful improvements in students' ethical competence when compared with traditional instruction. In testing Hypothesis 1, both the gain-score comparison and the covariate-adjusted analysis indicated that students learning with the framework (Groups A+B) achieved significantly higher overall ethical skill development than those in the traditional condition (Group C), supported by large effect sizes. These results suggest that embedding ethical learning tasks and reflective activities within a structured smart learning environment can produce substantial benefits beyond conventional teaching practices.

The multivariate evaluation of Hypothesis 3 further demonstrated that the framework-based condition outperformed traditional instruction on the combined outcomes of ethical awareness and moral reasoning after controlling for baseline scores. Follow-up analyses confirmed significant advantages for the framework group on each dimension, with a stronger effect observed for ethical awareness relative to moral reasoning. In addition, Hypothesis 5 was supported, showing that the framework condition achieved a significantly larger increase in ethical responsibility than the control condition, again with a large practical effect. Collectively, these results indicate that the proposed framework promotes both sensitivity to ethical issues and the capacity for reasoned ethical judgment, while also strengthening responsibility-oriented dispositions relevant to academic, professional, and digital contexts.

Findings related to teacher involvement revealed a differentiated pattern. Hypothesis 2 was not supported, as no statistically significant difference was observed in overall ethical skill development between the teacher-guided framework group (Group A) and the autonomous framework group (Group B), suggesting that the framework can function effectively under both facilitated and self-regulated conditions for broad ethical outcomes. However, Hypothesis 4 was supported, indicating that pedagogical scaffolding significantly enhanced reflective capacity compared to autonomous framework-based learning, with a large effect size. This result implies that teacher mediation may be particularly critical for deep reflective development even when overall ethical competence gains can be achieved through system-supported autonomous learning. Overall, the principal findings suggest that the proposed pedagogical framework is effective for ethical skill development, while also highlighting the specific pedagogical added value of teacher scaffolding for reflection-intensive learning outcomes.

4.2. Pedagogical Interpretation of the Framework Impact

The observed advantages of the proposed framework can be pedagogically interpreted as the cumulative effect of embedding ethical learning objectives into the learning process rather than treating ethics as an isolated content domain. In the framework-based condition, ethical competence was repeatedly activated through authentic dilemmas, structured reflection cycles, and iterative feedback, which together likely strengthened learners' ability to notice ethical issues, articulate value conflicts, and justify decisions in a reasoned manner. The substantial gains in overall ethical skills suggest that repeated exposure to scenario-based tasks created a routine of ethical sense-making, enabling students to move beyond declarative statements toward more operational forms of judgment and responsibility. The stronger effects observed for ethical awareness relative to moral reasoning are also pedagogically plausible, as awareness may respond more quickly to frequent prompting, guided attention to ethical cues, and systematic discussion of consequences, whereas moral reasoning development often requires longer-term practice in argumentation, perspective taking, and principle-based justification. Moreover, the improvement in ethical responsibility can be interpreted as a shift in students' perceived agency and accountability, supported by reflective activities such as journaling, self-assessment, and structured feedback that link individual choices to social and professional implications. In addition, the smart learning environment likely amplified these pedagogical mechanisms through consistency, personalization, and timely prompts that sustain engagement across sessions, ensuring that ethical learning experiences were not episodic but recurrent and traceable. From an instructional design perspective, the framework appears to function as a scaffolded pathway that coordinates ethical scenarios, reflective prompts, and assessment criteria into a coherent competence-development process, thereby reducing the common gap between ethics discourse and actionable ethical behavior in higher education contexts.

4.3. Role of Teacher Guidance and Scaffolding

The results indicate a differentiated role of teacher guidance within the proposed framework, suggesting that pedagogical scaffolding contributes selectively rather than uniformly across ethical learning outcomes. The non-significant difference in overall ethical skill development between the teacher-guided group and the autonomous framework group implies that the framework's built-in structure, including adaptive scenarios, reflective prompts, and feedback mechanisms, can support broad ethical competence gains even in the absence of continuous instructor mediation. This pattern is pedagogically meaningful because it suggests that well-designed smart learning environments may provide sufficient instructional orchestration for developing general ethical awareness, decision orientation, and responsibility-related dispositions, particularly when learning activities are standardized and repeatedly practiced. At the same time, the significant and practically large improvement in reflective capacity under teacher scaffolding highlights that reflection-intensive outcomes may require more nuanced pedagogical intervention than system-guided learning alone can consistently provide. Teacher facilitation can strengthen reflective depth by probing assumptions, challenging superficial justifications, and guiding learners toward more coherent integration of values, principles, and contextual constraints, especially when ethical dilemmas involve ambiguity or competing obligations. In this sense, teacher scaffolding may function as a catalyst for metacognitive regulation, helping students move from procedural reflection to critical reflection, where they interrogate the reasons behind their judgments and consider alternative interpretations. The findings therefore support a layered instructional implication: autonomous framework-based learning can be a viable model for scalable ethical skills training, while targeted teacher involvement remains strategically important for cultivating deeper reflective competence that underpins long-term ethical growth and transfer to complex real-world situations.

4.4. Cultural and Theoretical Contextualization

Interpreting the findings through a broader cultural and theoretical lens suggests that the proposed framework aligns with value-oriented educational traditions that conceptualize ethical development as a holistic, practice-based process rather than a narrow transmission of rules. Classical ethical thought associated with al-Farabi emphasizes the formation of virtuous dispositions through the integration of rational deliberation, character cultivation, and socially responsible conduct, a perspective that resonates with the framework's emphasis on repeated engagement with authentic dilemmas and principled justification. In a complementary manner, Ibn Sina's view of moral formation highlights the role of education, habit, and reflective discipline in shaping ethical agency, which parallels the framework's structured cycles of scenario analysis, reflection, and feedback that progressively stabilize ethical judgment as a learned competency. The ethical teachings associated with Khoja Ahmed Yassawi, with their focus on inner responsibility, humility, self-awareness, and service-oriented conduct, provide an additional interpretive foundation for understanding why reflective activities and responsibility-oriented tasks may generate measurable gains, particularly when learners are encouraged to connect ethical choices to broader human and societal implications. Within this contextualization, the smart learning environment can be viewed not merely as a technological container but as an infrastructure for sustained ethical practice, enabling consistent exposure to value conflicts, structured reflection, and accountability-oriented assessment. The convergence between the empirical results and these theoretical traditions strengthens the argument that ethical competence in higher education is best developed through pedagogically guided habituation of ethical thinking and action, culturally meaningful value articulation, and reflective self-regulation, all of which are operationalized in the framework through adaptive tasks and iterative learning processes.

4.5. Limitations, Implications, and Future Work

Several limitations should be considered when interpreting the findings and generalizing the proposed framework to broader higher education contexts. First, the quasi-experimental design and the use of a single institutional setting may limit external validity, as student characteristics, instructional culture, and digital infrastructure can influence ethical learning outcomes. In addition, despite efforts to standardize instructional conditions, the absence of random assignment limits the ability to fully rule out unobserved contextual or instructor-related effects. Consequently, the reported results should be interpreted as evidence of associative and differential effects rather than definitive causal relationships.

Second, the primary measures relied on questionnaire-based assessments, which, while practical for large-group evaluation, may be affected by self-report bias and may not fully capture behavioral manifestations of ethical competence in authentic academic or professional situations. Third, the intervention duration may have been sufficient to produce substantial gains in ethical awareness, responsibility, and general ethical skills; however, the development of more complex moral reasoning may require longer exposure, repeated practice across courses, and delayed post-testing to assess retention and transfer effects.

Despite these constraints, the study offers important implications for curriculum design and smart education policy. The results suggest that embedding ethical learning tasks and reflective activities into smart learning environments can yield meaningful competence gains at scale, supporting the integration of ethics as a cross-cutting learning outcome rather than a standalone module. Moreover, the differentiated findings regarding teacher guidance imply that institutions can adopt a blended implementation strategy, in which autonomous framework-based learning supports broad ethical development, while targeted teacher scaffolding is reserved for reflection-intensive learning objectives where deeper metacognitive regulation is required.

Future research should therefore extend the framework evaluation through multi-institutional replication, larger and more diverse samples, and randomized or longitudinal designs to further isolate instructional and contextual influences and strengthen causal inference. Additional studies should incorporate delayed post-tests and behavioral performance measures, such as scenario-based decision tasks, rubric-scored written justifications, or observed academic integrity behaviors. Further work may also explore discipline-specific adaptations of ethical scenarios, the role of individual differences in self-regulation, and the optimization of adaptive feedback algorithms to better support moral reasoning growth, thereby strengthening both the theoretical robustness and practical scalability of pedagogically grounded ethical education in smart learning environments.

5. Conclusion

This study proposed and empirically examined a pedagogical framework for ethical skill development in higher education within smart learning environments, with particular emphasis on integrating authentic ethical contexts, reflective learning cycles, and adaptive instructional support. Using a three-group quasi-experimental design, the findings indicate that students who learned with the proposed framework demonstrated substantially greater gains in overall ethical skills than those who received traditional instruction, and covariate-adjusted analyses confirmed that these advantages persisted after controlling for baseline differences. Multivariate results further showed that the framework enhanced the combined outcomes of ethical awareness and moral reasoning, while follow-up analyses clarified that the impact was especially pronounced for ethical awareness, suggesting that repeated exposure to ethically salient scenarios and structured prompts can rapidly strengthen learners' sensitivity to value conflicts. In addition, the framework produced strong improvements in ethical responsibility, indicating that adaptive ethical tasks and reflective activities can foster greater accountability and decision-oriented ethical agency in academically relevant contexts. The role of teacher guidance was found to be differentiated: overall ethical skill development did not significantly differ between teacher-guided and autonomous framework-based learning, yet pedagogical scaffolding yielded a substantial added benefit for reflective capacity. This pattern implies that smart learning environments can support scalable ethical competence development, while targeted instructor facilitation remains important for cultivating deeper reflection and metacognitive regulation. The study also contributes a culturally grounded interpretation by aligning the framework's emphasis on virtue formation, reflective self-discipline, and responsibility with value-oriented perspectives associated with al-Farabi, Ibn Sina, and Khoja Ahmed Yassawi. Overall, the results support the feasibility and educational value of embedding ethics as a competence-driven, process-oriented component of smart education, and they provide a foundation for future longitudinal and multi-institutional investigations that incorporate behavioral measures and discipline-specific adaptations.

Author Contributions Statement

Sultan Mukhamedaly – Conceptualization, Methodology, and Supervision: Proposed the core research idea, developed the theoretical framework, and supervised the overall research process.

Kymbat Kabekeyeva – System Design and Implementation: Designed and developed the AI-driven gamified learning environment and contributed to the technical architecture of the system.

Gulnar Mussabekova – Research Design and Data Collection: Coordinated the quasi-experimental study, organized participant involvement, and managed data collection procedures.

Aliya Kuralbayeva – Instrument Development and Validation: Designed the assessment rubric and questionnaire instruments and conducted reliability and validity analyses.

Bagdat Toibekova – Statistical Analysis and Interpretation: Performed statistical analyses, interpreted the results, and contributed to data visualization and reporting.

Gulzhan Makashkulova – Pedagogical Framework and Content Development: Developed instructional materials and ensured alignment between gamification elements and research skill competencies.

Batyrkhan Omarov – Writing, Editing, and Review: Contributed to manuscript drafting, critical revisions, formatting, and final approval of the submitted version.

All authors have read and agreed to the published version of the manuscript.

Conflict of Interest Statement

The authors declare no conflicts of interest.

Ethical Declarations

The authors declare that this study did not involve experiments on animals. Research activities involving human participants were conducted in accordance with institutional and national ethical standards. Informed consent was obtained from parents or legal guardians, and participation was voluntary. All data were anonymized to ensure confidentiality and privacy protection.

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Declaration of Generative AI in Scholarly Writing

During the preparation of this manuscript, generative AI tools were used solely to enhance language clarity, grammar, and overall readability. The technology was applied under full human oversight and control, and all generated text was carefully reviewed, edited, and verified by the authors to ensure accuracy, completeness, and academic integrity. No AI tools were used to generate research data, conduct statistical analyses, or draw scientific conclusions. Generative AI technologies are not listed as authors or co-authors. The authors take full responsibility for the content and integrity of this manuscript.

Abbreviations

The following abbreviations are used in this manuscript:

AI – Artificial Intelligence
GL – Gamified Learning
IGL – Inquiry-Based Learning
ANCOVA – Analysis of Covariance
MANOVA – Multivariate Analysis of Variance
NLP – Natural Language Processing
DL – Deep Learning
ICC – Intraclass Correlation Coefficient
SD – Standard Deviation

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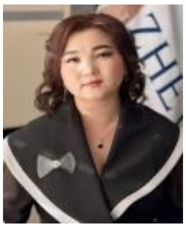

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