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Web-Based Career Simulation Game for Career Path Exploration Among Informatics and Computer Engineering Education Students

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ABSTRACT

This study aims to design and develop a web-based career simulation game as an interactive career exploration medium for students of Informatics Engineering Education. The study was motivated by students' limited understanding of information technology (IT) career pathways in Indonesia and the lack of contextual and engaging career exploration media. A preliminary study involving 51 students from two cohorts revealed that 70.6% had not yet decided on a career path, while 82.4% had never used a career simulation game. The development process adopted the Game Development Life Cycle (GDLC) methodology, which consists of six stages: Initiation, Pre-production, Production, Testing, Beta Release, and Release. The game was developed as a web-based application using a branching narrative system that simulates four career pathways (civil servant teacher, IT entrepreneur, postgraduate academic, and industry practitioner) through 46 interactive scenes and more than 120 decision points. Its main features include a multidimensional assessment system (interests, work–life balance, income, personal values, and job satisfaction), random events, and a career fit algorithm. Comprehensive evaluation demonstrated excellent results, including 100% validity in alpha testing (30 of 30 test cases passed using the Equivalence Partitioning technique), expert validation of 82.9% (highly feasible), career psychologist validation of 91.3% or 3.65 out of 4.00 (highly valid), average career-path content validation of 81.4% (highly feasible), practicality testing of 77.7% with 26 Informatics Engineering Education students (practical) and a Cronbach's Alpha coefficient of 0.924 (very high reliability), as well as an ISO 9126 evaluation with an overall mean score of 4.42 out of 5.00 (excellent), comprising Functionality (5.00), Usability (3.85), Reliability (4.33), and Efficiency (4.50). The findings indicate that the developed game is both feasible and practical as a career exploration tool for students of Informatics Engineering Education.

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1. INTRODUCTION

Career decision-making represents a significant challenge for university students during the transition from higher education to the workforce. Students of the Informatics Engineering Education (PTIK) program face increasingly complex career pathway choices in the digital era, ranging from becoming civil servant teachers, technology entrepreneurs, academics, to industry practitioners. Each career path has distinct characteristics in terms of financial stability, work-life balance, and long-term career satisfaction. A preliminary study involving 51 PTIK students from Institut Prima Bangsa Cirebon across two cohorts (fourth and eighth semesters) revealed that 70.6% had not yet made a definite career choice or remained uncertain about their future career paths [1], [2]. Regarding career-specific understanding, the findings showed that 45.1% of students had limited knowledge of the Civil Servant Teacher pathway, 37.3% of the IT Entrepreneurship pathway, 45.1% of the Academic/Postgraduate pathway, and 29.4% of the IT Industry Practitioner pathway. Furthermore, 54.9% of respondents reported that the available career information was insufficient or highly insufficient to support career decision-making, while 82.4% had never used games or simulations for career exploration. Nevertheless, 68.6% expressed strong interest in a career simulation game, with an average career importance score of 8.8 out of 10 and a career anxiety score of 7.7 out of 10, indicating an urgent and genuine need for interactive, contextual, and engaging career exploration media [3], [4], [5].

Game-Based Learning (GBL) and serious games have been widely recognized as effective approaches for increasing learner engagement across various educational contexts [6]. Simulation games enable students to experience virtual career scenarios and observe the consequences of their decisions without real-world risks. Narrative games employing branching systems are particularly suitable for career exploration because they provide meaningful choices that encourage critical thinking and self-reflection. The Game Development Life Cycle (GDLC) is a systematic and measurable framework for game development [7]. [8], [9] reported a validity score of 83.68% and a practicality score of 91.44% using the GDLC framework, while the ISO 9126 standard has been widely adopted to evaluate software quality by emphasizing functionality, usability, reliability, and efficiency.

The theoretical foundation of Game-Based Learning encompasses the framework of literacy and learning through video games, the input–process–outcome model that links motivation to learning outcomes in games, and conceptual foundations integrating instructional design with game mechanics. Empirical evidence supporting the effectiveness of GBL has been established through a systematic literature review of educational games, a meta-analysis of the cognitive and motivational effects of serious games, research on collaborative GBL in science education, and a review of GBL as a pedagogical innovation for developing twenty-first-century skills in vocational education [10], [11]. From the perspectives of design and evaluation, the alignment of game mechanics with learning outcomes, assessment frameworks for and within serious games, a systematic review of purposeful learning integration in games, gamified learning theory, and a comprehensive review of computer games in education provide essential references for designing the

evaluation mechanisms of educational games in this study. Additionally, the gamebook and branching narrative approach as design-based learning is closely aligned with the branching narrative architecture implemented in this research [12], [13].

Previous studies on career simulation games have been conducted in various contexts; however, several research gaps remain. A career-based game for adolescents aged 13–19 years aimed at enhancing career awareness. However, the game was designed for secondary education in the Netherlands and did not focus specifically on IT-related career pathways. Investigated the role of video game skills in supporting career planning competencies among secondary school students in Switzerland, but their study utilized commercial games that were not contextualized to career characteristics in Indonesia. Meanwhile, a web-based educational game was developed using the GDLC method for vocational high school Informatics learning in Indonesia, yet the study focused on instructional content rather than career exploration [14], [15], [16].

The identified research gaps encompass four major aspects. First, no career simulation game has been specifically developed for PTIK students in Indonesia that simulates the four primary career pathways using content contextualized to the Indonesian IT ecosystem. Second, previous studies have not integrated a comprehensive multidimensional scoring system capable of quantitatively representing the complex trade-offs involved in career decision-making. Third, the implementation of a highly complex branching narrative system that simulates the long-term consequences of career choices within the context of Indonesian higher education in information technology remains underexplored. Fourth, comprehensive evaluation of educational career games through expert validation, practicality testing, alpha testing, and ISO 9126 quality standards has received limited attention in the existing literature. Therefore, this study aims to address these gaps by developing a contextual, interactive web-based career simulation game and evaluating it comprehensively using the Game Development Life Cycle (GDLC) framework.

2. METHOD

This study employed a Research and Development (R&D) approach using the Game Development Life Cycle (GDLC) methodology, which consists of six phases: Initiation, Pre-production, Production, Testing, Beta Release, and Release [17]. The GDLC model was selected because it provides a systematic, organized, and measurable approach to educational game development [18].

In the Initiation phase, the problem was identified through a preliminary study using a structured questionnaire administered to 51 PTIK students at Institut Prima Bangsa Cirebon from two cohorts (Semester 4 and Semester 8). The results showed that 70.6% of students had not yet determined a clear career path (scores 1–3 on a 1–5 scale), with particularly low levels of understanding regarding the ASN Teacher pathway (45.1%), IT Entrepreneurship (37.3%), Academia/Master's Degree (45.1%), and Industry Practitioner careers (29.4%). In addition, 54.9% stated that available career information was insufficient, and 82.4% had never used a career simulation game. The target users were Semester 4–8 PTIK students, who are predominantly digital natives. Functional requirements included four career pathways with unique narrative flows and a multidimensional scoring system. Non-

functional requirements included browser compatibility, a load time of less than 3 seconds, and responsive design.

The Pre-production phase produced a comprehensive Game Design Document (GDD) through a three-layer content development process. The first layer involved a documentation study of relevant and verifiable secondary sources, including government regulations concerning ASN teachers (Minister of Education Regulation No. 6 of 2023 on teacher allowances; Minister of Administrative Reform Regulation No. 72 of 2020 on PPPK; Law No. 14 of 2005 on Teachers and Lecturers), official scholarship program data (LPDP), reports on the Indonesian IT labor market (Jobstreet Salary Report 2023; LinkedIn Salary Insights Indonesia 2023), and reports on the Indonesian startup ecosystem (DailySocial Startup Report 2022–2023; Katadata Insight Center 2023). These data served as the factual basis for all numerical values and conditions simulated in the game, including honorary teacher salaries, LPDP scholarship values, startup seed capital, and salary ranges for IT industry practitioners.

The second layer consisted of narrative scenario elaboration and development using an AI-assisted content development approach. The researchers used an AI language model as a synthesis tool to transform the collected factual data into contextual and engaging interactive narratives. In this process, the researchers acted as active curators who evaluated, adjusted, and validated all generated content for pedagogical relevance, factual accuracy, and Indonesian local contextualization. This approach aligns with the AI-assisted instructional design framework, which emphasizes the role of humans (human-in-the-loop) as the final decision-makers in AI-supported creative processes [19], [20].

The third layer involved content validation conducted sequentially by independent validators with distinct roles: (1) Subject Matter Expert (specialist in IT careers and vocational education), who assessed overall content accuracy and appropriateness; (2) Learning Media Expert, who evaluated interface design, navigation, and presentation mechanics; (3) Career/Vocational Psychologist, who assessed the psychological construct validity of the five scoring dimensions and the game mechanics from a career psychology perspective; and (4) four practitioners/experts, each representing one career pathway (ASN teacher, IT entrepreneur, master's-level academic, and IT industry practitioner), who validated the accuracy and realism of scenarios within their respective areas of expertise. This three-layer, multi-role validation process ensured that the developed content met standards of accuracy, pedagogical relevance, psychological construct validity, and contextual suitability for each career pathway before user testing was conducted.

The multidimensional scoring system was designed around five independent dimensions: Interest (passion and intrinsic motivation), Balance (work–life balance), Income (financial stability), Self-Worth (self-confidence and opportunities for growth), and Satisfaction (overall fulfillment). Each dimension began with a score of 50 on a 0–100 scale and could change based on the player's choices. The score-change range was intentionally asymmetric: negative effects could reduce scores by up to 20 points, whereas positive effects could increase scores by a maximum of 15 points. This design simulated the reality that poor career decisions tend to have greater negative consequences and are more difficult to recover from. A hard-fail system was implemented such that a score below 30 in any dimension

resulted in career failure, directing the player to a fail scene corresponding to the selected career pathway.

The selection of the five dimensions Interest, Balance, Income, Self-Worth, and Satisfaction was based on the understanding that career success is multidimensional and cannot be adequately represented by a single indicator. These dimensions collectively capture both intrinsic aspects, such as personal interest and self-worth, and extrinsic aspects, including financial outcomes, work-life balance, and overall career satisfaction. Together, they provide a more comprehensive representation of the factors that influence career decision-making and long-term career development [21], [22]. The asymmetric scoring mechanism, in which negative consequences produce larger score reductions than the corresponding positive gains, was intentionally designed to reflect the reality of career decision-making. In practice, unfavorable career outcomes such as burnout, financial difficulties, or failure to achieve professional goals often require considerably greater effort and time to overcome than the effort needed to attain comparable positive outcomes. By incorporating this mechanism into the game, students are encouraged to evaluate career choices more carefully, consider long-term consequences, and recognize that decisions involving significant risks may have lasting effects on future career development [23], [24].

The Indonesian local contextualization refers to publicly verifiable sources. The honorary teacher salary values presented in the game are simulated within a range of IDR 500,000 to IDR 2,500,000 per month, based on two references: the regulation governing the allocation of School Operational Assistance (BOS) funds, which permits a maximum of 50% of BOS funds to be allocated for the salaries of non-civil servant teachers (Regulation of the Minister of Education, Culture, Research, and Technology No. 63 of 2023), and the national survey conducted by the Institute for Demographic and Poverty Studies in collaboration with Dompet Dhuafa (2024), which reported that the majority of honorary teachers earn less than IDR 2 million per month, with some receiving less than IDR 500,000 per month (Media Indonesia, 2024). The value of IDR 2.5 million used in the game represents a realistic upper bound of this salary range rather than an officially standardized national salary, considering that actual remuneration varies substantially across regions. The LPDP scholarship value for domestic master's degree programs is based on the official information available at lpdp.kemenkeu.go.id. The startup initial capital of IDR 15 million refers to the seed capital range for digital micro-enterprises reported in the *DailySocial Startup Report* (2022). The junior IT developer salary range of IDR 6–8 million is based on the *JobStreet Indonesia Salary Report* (2023). All career challenge scenarios, including family pressure, professional conflicts, and work-life balance dilemmas, were developed from patterns documented in career development literature and published case studies (Van der Kooij et al., 2023; Hoffelner et al., 2024), and were subsequently elaborated and contextualized for Indonesian Information Technology Education (PTIK) students.

The Production phase implemented the design using HTML5, CSS3, and Vanilla JavaScript following the Object-Oriented Programming (OOP) paradigm. The game engine was developed using a modular architecture consisting of a Narrative Engine for scene transitions, a Consequence System for applying scoring effects, a Random Events Generator comprising eleven independent events with occurrence probabilities ranging from 10% to

15% per scene (the probability of at least one event appearing in each scene, based on a simulation of 5,000 trials using the actual source code, reached approximately 75%), a Multidimensional Scoring Algorithm, and a Career Fit Calculator. Narrative content was developed across 46 scenes with particular attention to realism and emotional engagement. Visual assets employed consistent color schemes for each career pathway: green for Civil Servant Teachers (ASN), orange for IT Entrepreneurs, blue for Master's Degree Academics, and purple for Industry Professionals. Internal testing covered functionality, compatibility, responsiveness, and performance profiling. Detailed measurements of load time, response time, and memory usage are presented in the Results section after the completion and documentation of all internal testing sessions.

The Testing phase employed black-box testing using the Equivalence Partitioning (EP) technique to validate system functionality through 30 test cases grouped into six testing categories: Home Screen & Initialization, Gameplay & Scoring, Hard Fail, Random Events, Result Screen & Career Fit, and Navigation & Keyboard Shortcuts, covering all user journeys from happy-path scenarios to edge cases and boundaries. Each test case was planned to be executed at least three times to ensure consistency of results. Test cases involving purely logical functions that were independent of browser visual rendering were verified through automated code execution against the game source files, whereas test cases dependent on DOM rendering and visual interactions were verified manually by the researcher [25].

The Beta Release phase incorporated three evaluation approaches. First, expert validation was conducted by instructional media experts, subject matter experts, a career psychologist, and practitioners representing each career pathway using Likert scales (1–4 for the career psychologist instrument and 1–5 for the instructional media, subject matter, and career practitioner instruments). Validation results were analyzed using percentage formulas, with interpretation categories classifying scores between 81% and 100% as Highly Feasible/Highly Valid. Second, a practicality test was conducted with 26 PTIK students using a 17-item questionnaire developed by integrating practicality indicators proposed by Nieveen covering Usability, Engagement, and Content Relevance with the usability sub-characteristics of ISO 9126, namely Understandability, Learnability, and Operability. This integration enabled a single evaluation session to produce practicality data (12 core items) simultaneously and ISO 9126 usability quality data (8 selected items), following the approach adopted by [25]. Instrument reliability was assessed using Cronbach's Alpha after data collection. Observations of participants' behavioral patterns complemented the evaluation. Third, the ISO 9126 evaluation covered Functionality (completeness, correctness, interoperability), Usability (learnability, understandability, operability; measured using the practicality instrument described above), Reliability (availability, fault tolerance, recoverability), and Efficiency (time behavior and resource utilization).

The Release phase deployed the game to GitHub Pages, a static hosting platform supported by a Content Delivery Network (CDN) managed through GitHub/Microsoft infrastructure, providing automatic HTTPS and built-in Gzip compression. GitHub Pages was selected based on its technical suitability, as the game was developed entirely using HTML5, CSS3, and JavaScript without any server-side processing, eliminating the need for

paid hosting services or specialized server configurations. GitHub Pages distributes content through a global CDN, ensuring optimal accessibility across Indonesia, as confirmed by the availability test (Reliability R1), which recorded 100% uptime throughout the 14-day testing period. The game was made publicly accessible via https://hamam-jr.github.io/karirmupilihanmu/ and disseminated to fourth- through eighth-semester PTIK students through QR code distribution in classrooms, WhatsApp group links, and the institutional Learning Management System (LMS).

3. RESULTS AND DISCUSSION

Results of the Initiation through Production Stages

The initiation stage resulted in a comprehensive understanding of the target users' needs through a preliminary study using a structured questionnaire. The findings revealed that 70.6% of students had not yet decided on or were still uncertain about their career path (scores of 1–3 on a 1–5 scale). Limited understanding was observed for the Civil Servant Teacher (45.1%), IT Entrepreneur (37.3%), Academic/Postgraduate (45.1%), and Industry Practitioner (29.4%) career paths. Additionally, 54.9% of respondents indicated that the available career information was insufficient or highly insufficient, while 82.4% had never used a career simulation game. These findings served as the foundation for the problem definition and requirements specification in the game development process.

Students expressed the need for an interactive learning medium that would enable them to explore career pathways through simulation, make decisions within realistic scenarios, and understand the trade-offs among different career aspects without facing real-world risks. These findings further informed the problem definition and requirements specification for the game development.

The pre-production phase produced a comprehensive Game Design Document (GDD) that thoroughly documented the game's architecture, gameplay mechanics, narrative content, UI/UX design, and technical specifications. The game architecture adopted a hierarchical structure consisting of four career pathways, each comprising ten scenes, resulting in a total of 46 interactive scenes with more than 120 decision points representing the complexity of career journeys over a period of three to five years. A multidimensional assessment system was designed with five dimensions representing the fundamental aspects of career satisfaction and success, based on the literature and discussions with PTIK students. The scoring mechanism was initialized with a starting score of 50 and employed an asymmetric scoring range, reflecting the reality that poor decisions generally have greater negative consequences and are more difficult to recover from than positive outcomes.

The UI/UX design adopted a glassmorphism aesthetic, with wireframes developed for the home screen, gameplay screen, and result screen, emphasizing accessibility. The color palette was selected to create intuitive associations, using green for the Civil Servant Teacher pathway, orange for IT Entrepreneur, blue for Academic/Postgraduate, and purple for Industry Practitioner. A responsive design approach ensured an optimal viewing experience across desktop and tablet devices.

The production phase implemented the approved design using standard web technologies to maximize compatibility. The software architecture followed a modular

design by separating game_data.js, which stores the narrative content in JSON format, from app.js, which implements the game logic using a class-based object-oriented programming (OOP) approach. The results of load time, response time, and memory usage measurements from internal testing are reported in detail in the Efficiency section of the ISO 9126 evaluation (Table 4).

Testing Phase Results

Alpha testing was conducted using the Equivalence Partitioning (EP) technique, which divided the game's functional domain into 30 test cases across six testing groups: (1) Home Screen & Initialization, (2) Gameplay & Scoring, (3) Hard Fail, (4) Random Event, (5) Result Screen & Career Fit, and (6) Navigation & Keyboard Shortcut (Pressman, 2010; Myers et al., 2011). Each test case was executed at least three times to ensure result consistency. Several test cases involving purely logical processes, including the effects of player choices on scores, the hard fail mechanism, score clamping within the 0–100 range, and random event probability, were verified through code-level automated testing by directly executing the game source files (*game_data22.js* and *app.js*), independent of browser-based interface rendering. The results of the automated testing are presented in Table 1.

Table 1. Results of Code-Level Automated Testing

Code	Test Description	Supporting TC	Result
STRUCT-01	Each career path contains 10 scenes and 1 fail scene	TC-004–007, TC-016–019	Valid
STRUCT-02	All nextScene references point to existing scenes (no broken links)	Supports integrity of all test cases	Valid
STRUCT-03	All choice-effect keys correspond to the five valid scoring dimensions	TC-008–010	Valid
STATIC-01	The executed FAIL_THRESHOLD value is 30 (synchronized with the article and instrument)	TC-014, TC-015	Valid
TC-014	A score exactly at the threshold (30) does not trigger failure	TC-014	Valid
TC-015	A score one point below the threshold (29) triggers failure	TC-015	Valid
TC-016	Teacher (Civil Servant) career path fail scene is available for redirection	TC-016	Valid
TC-017	IT Entrepreneur career path fail scene is available for redirection	TC-017	Valid
TC-018	Master's Academic career path fail scene is available for redirection	TC-018	Valid
TC-019	Industry Practitioner career path fail scene is available for redirection	TC-019	Valid
TC-011	Score does not exceed 100 despite large positive effects	TC-011	Valid
TC-012	Score does not fall below 0 despite large negative effects	TC-012	Valid
TC-020/021	Random event mechanism is triggered according to the designed probability (5,000-trial simulation)	TC-020, TC-021	Valid

Thirteen of the thirty test cases above focused on code logic independent of browser rendering and were therefore verified through automated testing, while the remaining seventeen test cases were validated directly through browser-based visualization. All 30 test cases achieved a Valid status, resulting in a 100% success rate.

Table 2. Summary of Black Box Testing Results (30 Test Cases Across 6 Groups)

Group	Number of TCs	Valid	Invalid	Success Rate
Home Screen & Initialization	7	7	0	100%
Gameplay & Scoring	6	6	0	100%
Hard Fail	6	6	0	100%
Random Event	3	3	0	100%
Result Screen & Career Fit	3	3	0	100%
Navigation & Keyboard	5	5	0	100%
Total	30	30	0	100%

Beta Release Results

Content validation was conducted sequentially by four independent validator groups: Subject Matter Expert, Educational Media Expert, Career Psychologist, and practitioners representing each career pathway.

Subject Matter Expert and Educational Media Expert Validation

The Subject Matter Expert evaluated 28 items related to content appropriateness, scenario relevance, and career information accuracy using a five-point Likert scale. The evaluation yielded a total score of 115 out of 140 (mean = 4.11), equivalent to 82.1%, which falls within the Highly Feasible category. The Educational Media Expert assessed 27 items covering visual design, navigation, accessibility, and the effectiveness of game mechanics. The evaluation resulted in a total score of 113 out of 135 (mean = 4.19), equivalent to 83.7%, also categorized as Highly Feasible. The combined evaluation of both experts produced an overall feasibility score of 82.9% (mean = 4.15/5.00), indicating that the game is Highly Feasible for implementation.

Table 3. Validation Results by Subject Matter and Educational Media Experts

Validator	Number of Items	Maximum Score	Obtained Score	Mean	Percentage	Category
Subject Matter Expert	28	140	115	4.11	82.1%	Highly Feasible
Educational Media Expert	27	135	113	4.19	83.7%	Highly Feasible
Overall Average	55	275	228	4.15	82.9%	Highly Feasible

Psychological Construct Validation (Career Psychologist)

Psychological construct validation was conducted by a licensed Clinical Psychologist (B.Psych., M.Psych., Psychologist) with 18 years of professional experience using a 23-item instrument rated on a four-point scale. The instrument covered three aspects: (A5) general content validity and Indonesian contextualization, (B) psychological construct validity of the five scoring dimensions based on RIASEC Theory, Self-Determination Theory, Social Cognitive Career Theory, and Prospect Theory, and (C) validation of game mechanics and pedagogical design from the perspective of career psychology.

Table 4. Psychological Construct Validation Results

Aspect	Evaluation Focus	Number of Items	Maximum Score	Obtained Score	Mean
A5	General Content & Indonesian Contextualization	4	16	16	4.00
B	Psychological Constructs of the Scoring Dimensions (B1–B6)	12	48	44	3.67
C	Game Mechanics & Learning (Career Psychology Perspective)	7	28	24	3.43
Total	Overall	23	92	84	3.65 / 4.00

The total score of 84 out of 92 (91.3%, mean = 3.65/4.00) falls within the Highly Valid category according to the interpretation rubric used (3.26–4.00 = Highly Valid). In the qualitative conclusion section, the validator selected the "Valid" category and recommended that the game was "appropriate for use with minor revisions." Therefore, both the quantitative score and the validator's holistic qualitative judgment are reported transparently. Five revision recommendations were provided:

1. Add a disclaimer stating that the career fit score serves only as reflective feedback and is not a psychological diagnosis or a formal career assessment.
2. Ensure consistency in the number of scenes and decision points across the Game Design Document (GDD), validation documents, and the game implementation.
3. Provide a transparent explanation of the five-dimensional scoring mechanism.
4. Use supportive and non-judgmental narratives for failure and burnout scenarios.
5. Update and cite local data sources, including salary ranges, scholarship opportunities, and IT career prospects, with the corresponding publication year to facilitate verification.

All recommendations have been or will be implemented as part of the iterative Game Development Life Cycle (GDLC).

Career Path Content Validation

In addition to the general validation process, each career pathway was independently reviewed in depth by a practitioner or expert representing the respective professional field. An 18-item instrument rated on a five-point Likert scale was employed to evaluate the accuracy of scenarios, the appropriateness of financial values presented, and the realism of response options within each career pathway.

Table 5. Content Validation Results by Career Path

Career Path	Number of Items	Maximum Score	Obtained Score	Percentage	Category
Civil Servant Teacher (ASN)	18	90	64	71.1%	Feasible
IT Entrepreneur	18	90	82	91.1%	Highly Feasible
Master's Degree/Academic	18	90	74	82.2%	Highly Feasible
IT Industry Practitioner	18	90	73	81.1%	Highly Feasible
Average	72	360	293	81.4%	Highly Feasible

The overall average score of 81.4% falls into the Highly Feasible category. However, the Civil Servant Teacher (ASN) career path obtained the lowest score (71.1%, Feasible) compared with the other three career paths, all of which achieved scores above 80%. These findings indicate that, relative to the other career paths, the Civil Servant Teacher scenario requires further revision to improve the accuracy and realism of its content before being used in the practicality testing with students. This issue should also be highlighted in the Discussion and Research Limitations sections.

Practicality Test Results and ISO 9126 Evaluation

The practicality test involved 26 students from the Information Technology Education Program (PTIK), Institut Prima Bangsa Cirebon, using a 17-item instrument integrating Nieveen's practicality indicators with the Usability sub-characteristics of ISO 9126. The results showed a total score of 1,212 out of a maximum possible score of 1,560 for the 12 core practicality items, equivalent to 77.7%, which falls into the Practical category. The overall Cronbach's Alpha for the 17-item instrument reached 0.924 (Very High), while all 12 core items demonstrated corrected item-total correlation values of $r \geq 0.30$, indicating that all items were valid. Table 3 summarizes the practicality results for each dimension.

Table 6. Practicality Test Results with 26 PTIK Students (10 of 17 Representative Items)

Statement	Mean	SD	Category
Easy to use without lengthy tutorials	3.84	0.47	Practical
The interface is intuitive and not confusing	3.58	0.71	Practical
I immediately understood how to play from the home page	3.77	0.65	Practical
Career path descriptions are clear on the initial page	3.81	0.57	Practical
Buttons and interface elements are easy to click/tap	4.15	0.46	Highly Practical
I remained focused and engaged while playing	3.96	0.52	Practical
The random events feature increases engagement	3.92	0.63	Practical
The duration of playing one career path is sufficient	3.77	0.65	Practical
The content is relevant for career path exploration	3.88	0.52	Practical
The game helps me understand the differences among the four IT career paths	4.00	0.49	Practical
OVERALL AVERAGE (All 17 Items)*	3.87	0.41	Practical

The ISO 9126 evaluation covered four external quality characteristics. Functionality achieved a perfect score of 5.00 (Excellent) based on 30 out of 30 valid test cases (100%) using the Equivalence Partitioning technique. Usability obtained a score of 3.85 (Good) based on eight items integrated into the practicality questionnaire (Items 2, 3, 4, 5, 11, 13, 16, and 17). The highest-rated item was Item 5, *"Buttons are easy to click,"* with 83.1%, while the lowest-rated was Item 2, *"The interface is intuitive,"* with 71.5%. Reliability achieved an average score of 4.33 (Excellent), comprising R1 Availability = 5.00 (14/14 monitoring days with 100% uptime), R3 Fault Tolerance = 5.00 (10/10 normal operating scenarios), and R6 Recoverability = 3.00 (6/10 restart tests successful). In two restart sessions, the score failed to return to the default value of 50, indicating a state management bug that should be prioritized for improvement. Efficiency obtained a score of 4.50

(Excellent), with E3 loading the result screen completed in 1.98 seconds (score 5), E4 memory usage peaking at 2.6 MB (score 5), and E5 CPU utilization showing only a 2.4% increase between idle and active states (score 5). Indicators E1, E2, and E6 each received a score of 4 because they slightly exceeded the target values while remaining within acceptable tolerance limits.

Table 7. ISO 9126 Quality Evaluation Results

ISO 9126 Aspect	Sub-characteristics	Mean Score	Category	Interpretation
Functionality	Completeness, Correctness, Interoperability	5.00	Excellent	30/30 test cases (100%) valid
Usability	Understandability, Learnability, Operability	3.85	Good	Based on the integrated 17-item practicality questionnaire
Reliability	Availability (R1 = 5), Fault Tolerance (R3 = 5), Recoverability (R6 = 3)	4.33	Excellent	14/14 days uptime; 10/10 normal scenarios; 6/10 restart tests successful
Efficiency	Time Behaviour (E1, E2, E6 = 4; E3 = 5), Resource Utilization (E4, E5 = 5)	4.50	Excellent	Maximum memory usage 2.6 MB; CPU increase 2.4%; satisfactory response time
OVERALL AVERAGE	—	4.42	Excellent	Meets the international quality standard of ISO 9126

Release Phase Results

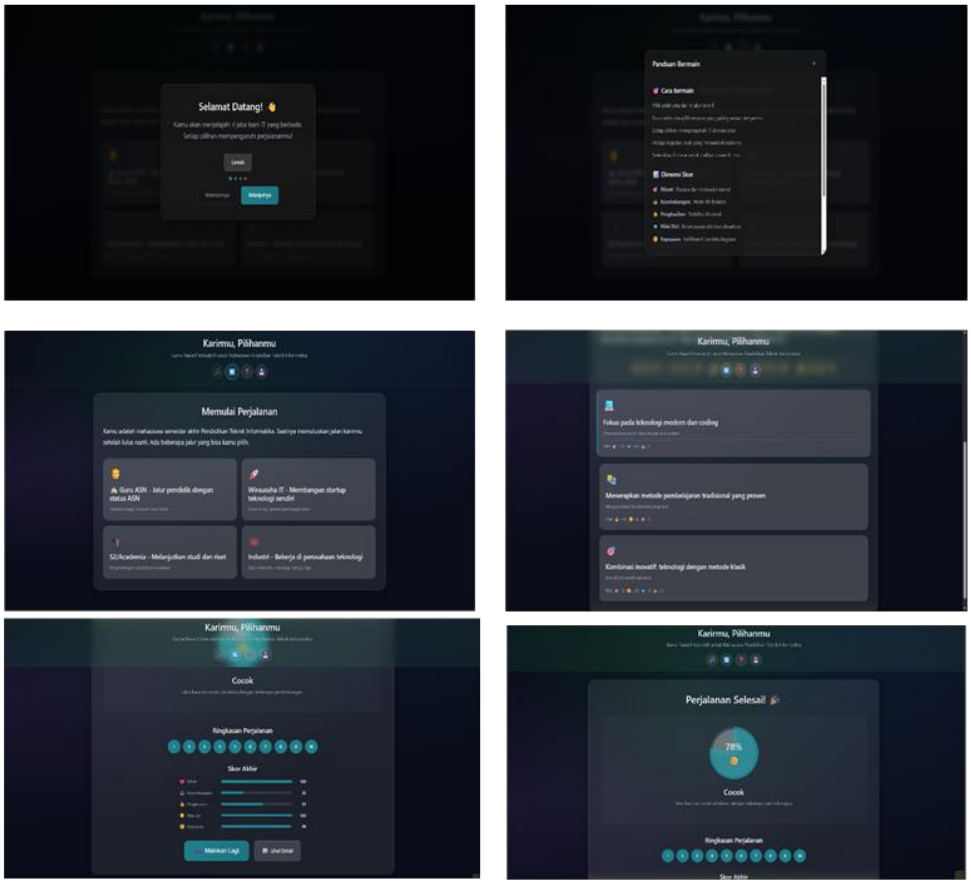

Figure 2. Game Interface

The game was deployed through GitHub Pages, providing a public URL that can be accessed directly through any web browser without additional installation. This platform was selected because it offers an automatic Content Delivery Network (CDN), built-in HTTPS, and Gzip compression without manual configuration, making it well suited for a static web application developed using HTML5, CSS3, and JavaScript. The reliability of the deployment was confirmed through the ISO 9126 Reliability evaluation (R1 Availability = 5.00), where monitoring over 14 consecutive days showed 100% uptime, indicating uninterrupted availability throughout the testing period. The user interface of the game on each main screen is presented in Figure 2.

Discussion

The results of the comprehensive evaluation indicate that the Game Development Life Cycle (GDLC) was effective in producing a high-quality product in terms of content, psychological construct, practicality, and technical quality. Validation by the Subject Matter Expert and Media Expert reached 82.9% (Highly Feasible), Career Psychologist validation reached 91.3% or 3.65/4.00 (Highly Valid), career-path content validation by practitioners averaged 81.4% (Highly Feasible), the practicality test involving 26 Information Technology Education (PTIK) students yielded 77.7% (Practical) with a Cronbach's Alpha of 0.924 (Very High), and the ISO 9126 evaluation produced an average score of 4.42/5.00 (Excellent). The "Practical" category obtained in the practicality test is methodologically valid, although the Ease of Use dimension recorded the lowest score (75.4%). The Engagement and Attractiveness dimension achieved the highest score (79.7%), indicating that the interactive narrative features and random events successfully created an engaging gameplay experience. This finding is consistent with qualitative feedback indicating that the game provides a realistic representation of career pathways, although several participants experienced navigation difficulties during their first gameplay session.

The hard-fail mechanism, implemented with a score threshold below 30, demonstrated educational value by highlighting the consequences of unbalanced decision-making. This was confirmed through qualitative feedback stating that the mechanism realistically illustrated the risks associated with poorly planned career decisions. Nevertheless, the ISO 9126 Reliability evaluation (R6: Recoverability, score = 3) identified a state-management bug: in two of the eight restart sessions tested, player scores did not fully reset to the initial value of 50. This issue has been identified as a priority for iterative improvement before final deployment and indicates the need to strengthen the state-reset mechanism within the game engine.

A comparison with the study by [25], which reported 83.68% validity and 91.44% practicality, shows that the content validation results of the present study (82.9–91.3%) fall within a comparable range. Regarding practicality, the obtained score of 77.7% is lower than that reported by Kurniawan et al. (91.44%) but still falls within the Practical category, despite the substantially higher narrative complexity of this game (46 scenes compared to 15–20 scenes). Furthermore, the overall ISO 9126 score of 4.42 (Excellent) exceeds those reported in comparable studies, which generally range between 3.5 and 4.0, indicating that

although usability can still be improved, the technical quality of this web-based educational game surpasses the typical standards of similar educational games.

The balanced scoring mechanism incorporating asymmetric effects was shown to enhance the game's educational value, as assessed by the Career Psychologist. According to the psychologist, the mechanism is conceptually valid for simulating career-risk asymmetry, reflecting real-world conditions in which reputation damage is more difficult to recover than reputation gain, burnout recovery requires more time than productivity improvement, and financial losses have a greater impact than equivalent financial gains. Likewise, the hard-fail mechanism with a threshold score below 30 in any dimension enhances realism by communicating that extreme imbalance may result in career failure, such as teacher resignation due to burnout, startup bankruptcy caused by prolonged negative cash flow, withdrawal from graduate studies because of mental and financial pressures, or resignation from a company due to a toxic work environment affecting mental well-being.

The branching narrative complexity implemented in this study (46 scenes, more than 120 decision points, and four parallel career paths) exceeds that of most web-based educational games reported in related studies, which generally contain 15–25 scenes with 30–50 decision points. This level of complexity generates exponential branching possibilities, with a theoretical maximum of 3^{10} (59,049) unique paths per career, although the actual number of unique paths is reduced through narrative convergence and fail conditions. The game's replayability potential will be empirically evaluated through behavioral observations in future practicality testing.

Research Contributions

This study provides several theoretical and practical contributions to the fields of game-based learning and career exploration for Information Technology Education (PTIK) students. From a theoretical perspective, this study makes three primary contributions. First, it is the first to develop a career simulation game specifically designed to simulate the four primary career pathways of PTIK graduates in Indonesia using content contextualized to the Indonesian IT ecosystem. This addresses a research gap identified in previous studies, which primarily focused on international contexts or did not specifically target the IT discipline. Second, this study develops a multidimensional scoring framework consisting of five dimensions that quantitatively represent the complexity of career decision trade-offs, thereby contributing to the advancement of decision-impact evaluation mechanisms in serious games. Third, the implementation of a highly complex branching narrative system combined with probabilistic random-event mechanisms represents an innovative approach to simulating realistic career exploration, a feature rarely found in previous web-based career education games.

From a practical perspective, the primary contribution of this research is the availability of a fully functional web-based career simulation game that can be accessed free of charge by PTIK students throughout Indonesia to support independent career exploration or integration into formal learning activities. The game can also be adapted by other study programs within the IT or STEM fields by modifying the career-path content to suit their respective academic contexts. Furthermore, the GDLC methodology applied in this research

provides a systematic guideline for researchers and developers in developing high-quality web-based educational games, while the comprehensive evaluation framework combining expert validation, practicality testing, alpha testing, and ISO 9126 assessment may serve as a quality evaluation standard for educational games in Indonesia.

Research Limitations

This study has several limitations that should be acknowledged. First, the content validation involved only one validator for each expert role; involving two or more validators per role would improve inter-rater reliability. Second, the practicality test involved only 26 students from a single institution, limiting the generalizability of the findings. Third, subscales consisting of only three items produced artificially lower Cronbach's Alpha values than the overall reliability coefficient (0.924), which is a common limitation of short subscales. Fourth, the Reliability evaluation identified a state-management bug in the restart mechanism (R6 = 3, Fair), whereby player scores did not consistently reset to the initial value of 50 in two out of eight testing sessions; this issue should be addressed in future development iterations. Fifth, the game content does not yet cover IT sub-specializations such as data science, cybersecurity, and cloud computing. Sixth, the random-event system remains generic and has not yet been adapted to player profiles or learning analytics to provide personalized learning experiences. Finally, the relatively lower validation score for the Civil Servant Teacher (Guru ASN) career pathway (71.1%) compared with the other three pathways indicates the need for more comprehensive content revision before subsequent practicality testing is conducted.

4. CONCLUSION

The development of a web-based career simulation game using the Game Development Life Cycle (GDLC) method has produced a product that was validated through multiple stages and evaluated comprehensively. A preliminary study involving 51 Information Technology Education (PTIK) students from two cohorts confirmed a genuine need for the application: 70.6% had not yet established a clear career direction, 54.9% considered the available career information insufficient, and 82.4% had never used a career simulation game. The game simulates four career pathways through 46 interactive scenes featuring more than 120 decision points. The comprehensive evaluation demonstrated excellent results, including 100% validity in alpha testing (30/30 test cases passed), feasibility scores of 82.9% (Highly Feasible) from both the Subject Matter Expert and Media Expert, a score of 91.3% (3.65 out of 4.00; Highly Valid) from the Career Psychologist, an average content validation score of 81.4% (Highly Feasible) across all career pathways, a practicality score of 77.7% (Practical) from 26 PTIK students with a Cronbach's Alpha of 0.924 (Very High), and an average ISO 9126 evaluation score of 4.42 out of 5.00 (Excellent), comprising Functionality (5.00), Usability (3.85), Reliability (4.33), and Efficiency (4.50).

This study contributes theoretically by proposing a multidimensional scoring system framework, implementing a high-complexity branching narrative system, and introducing a comprehensive evaluation framework that integrates expert validation, practicality testing, alpha testing, and ISO 9126 quality evaluation. Its practical contributions include the

availability of a career simulation game accessible to PTIK students throughout Indonesia, a systematic GDLC implementation guideline, and an evaluation standard that future researchers can adopt. Recommendations for future development include addressing the state management bug (R6), improving the onboarding process to enhance usability, expanding content to include IT sub-specializations such as data science, cybersecurity, and cloud computing, implementing adaptive features based on player profiles, and developing an analytics dashboard to support career counselors.

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