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Prototype Development of a Gamified Mobile Learning System for Fashion Design Education Using Design Thinking

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ABSTRACT

Fashion Design Education requires learning approaches that integrate visual content, interactive exploration, and progressive learning activities. However, conventional learning media may provide limited opportunities for students to explore fashion concepts through interactive and gamified learning experiences. This study aimed to develop FashionSim, a gamified mobile learning prototype designed to support the learning of style and look concepts in Fashion Design Education, and to assess its feasibility and perceived usability. The study employed a Research and Development (R&D) approach using the Design Thinking framework, comprising five stages: empathize, define, ideate, prototype, and test. These stages guided the identification of learner requirements and their translation into instructional content, interface design, gamification elements, and interactive learning activities. The resulting prototype integrates structured learning materials, progressive learning levels, game challenges, mix-and-match activities, achievement features, and interactive assessments within a mobile learning environment. Product feasibility was assessed by two experts, consisting of one material expert and one media expert, while usability testing involved 30 students. Feasibility data were analyzed descriptively by comparing the obtained scores with the maximum possible scores, while perceived usability was measured using the System Usability Scale (SUS). The material expert assessment yielded a feasibility score of 91%, while the media expert assessment yielded 92%, resulting in an overall feasibility score of 91.5%, categorized as highly feasible. Usability testing produced an SUS score of 83.5, indicating excellent perceived usability and

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an acceptable level of usability. These findings provide evidence of the prototype's feasibility and perceived usability as a gamified mobile learning medium for Fashion Design Education. Further research involving implementation in authentic learning environments is needed to examine its potential contribution to learning effectiveness, learning gains, and other educational outcomes.

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1. INTRODUCTION

The rapid development of digital technology has created new opportunities for transforming learning in higher education toward more flexible, interactive, and learner-centered experiences (Lu et al., 2022). This transformation is particularly relevant to Fashion Design Education, where students are required not only to understand theoretical concepts but also to interpret visual characteristics and make design decisions involving silhouette, color, material, and styling context. In learning style and look, conventional instructional practices that rely heavily on lectures, static visual presentations, and two-dimensional references may provide conceptual information but offer limited opportunities for interactive exploration and simulated design decision-making. To further identify these learning needs, a preliminary needs analysis was conducted through interviews with a course lecturer and 10 students selected from a total of 30 students. The interviews explored learning challenges and the need for more interactive learning experiences in understanding style and look concepts. The findings highlighted the need for learning media that facilitates visual exploration, interactive mix-and-match activities, progressive learning experiences, and feedback. These findings subsequently informed the design of FashionSim, particularly its visual learning materials, progressive learning levels, mix-and-match activities, game challenges, and interactive assessments.

Mobile learning provides an opportunity to address these needs by enabling learning resources and activities to be accessed through mobile devices (Lazaro & Duart, 2023). Research in higher education has demonstrated the growing use of mobile learning and its potential to support flexible access, interaction, and learner-centered learning experiences (Naveed et al., 2023). Within Fashion Design Education, mobile learning applications have been developed to support specific instructional activities, including pattern-making instruction and digital fashion design learning (İnci & Çileroğlu, 2025; Yusuf et al., 2021). Research has also explored the relationship between fashion design and digital game design in educational contexts, particularly in creating fashion-related experiences in digital environments (Tepe & Koohnavard, 2023). These studies demonstrate the potential of digital technologies to support fashion-related learning activities. However, the integration of mobile learning, fashion-specific interactive activities, and gamification mechanisms within a structured learning environment for style and look concepts remains an area for further development.

Gamification offers a complementary approach for increasing interaction and engagement by incorporating game elements into learning activities (Li et al., 2024). Unlike game-based learning, which uses games as the primary medium for learning, gamification integrates selected game design elements into an existing learning environment (Krath et al., 2021). In this study, gamification is implemented through progressive levels, points, achievements, challenges, feedback, and retry functions, while the instructional content remains the central component of the learning experience. Recent systematic reviews and meta-analyses indicate that gamification can contribute

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to student motivation, engagement, and academic performance, although its effects depend on how game elements are selected, combined, and aligned with instructional objectives (Khaldi et al., 2023). In Fashion Design Education, gamified learning activities can potentially organize fashion-related learning through visual challenges, progressive levels, mix-and-match simulations, achievement systems, and interactive assessments (Tepe & Koohnavard, 2023). Research specifically addressing gamification in Fashion Design Education also indicates an emerging interest in connecting game-based approaches with fashion-related learning experiences (Al-Hafdi & Alhalafawy, 2024). Nevertheless, the integration of these mechanisms into a mobile learning environment specifically structured around style and look learning remains limited.

Design Thinking provides a suitable human-centered approach for addressing this development challenge because it emphasizes understanding users, defining problems, generating solutions, prototyping, and testing iteratively (Dell'Era et al., 2025). Its relevance in educational contexts is supported by a recent meta-analysis indicating that Design Thinking can contribute positively to student learning, including engagement, motivation, problem-solving, and academic achievement (Yu et al., 2024). In educational technology development, this approach enables product features to be derived from identified learner needs rather than being determined solely by technological possibilities (Arrasyid et al., 2024). In the present study, Design Thinking was therefore used to translate the identified needs of Fashion Design learners into the instructional structure, interaction design, and gamification features of the proposed mobile learning prototype.

Despite the growing body of research on mobile learning, gamification, and Design Thinking, their application to specific learning needs in Fashion Design Education, particularly in learning style and look concepts, remains an area that requires further exploration. Existing studies have generally examined these approaches separately or focused on specific learning activities (Dahalan et al., 2024). The novelty of this study lies in translating the specific learning needs of Fashion Design students into contextualized gamification mechanisms within a mobile learning prototype. Rather than merely incorporating conventional game elements, the prototype integrates fashion-related learning activities through visual exploration of style and look concepts, progressive learning levels, mix-and-match activities, and theme-based design challenges. These mechanisms are structured to guide students from recognizing fashion styles and understanding contextual looks to applying their knowledge through visual composition and design challenges. Design Thinking is employed to guide the translation of identified user needs into the prototype's instructional structure, interaction design, and gamification features. Thus, this study contributes a context-specific gamified mobile learning prototype that connects fashion design learning activities with structured and interactive learning experiences.

Accordingly, this study aims to develop and validate a gamified mobile learning prototype for Fashion Design Education using Design Thinking. The study specifically examines the feasibility of the prototype through material and media expert validation and its perceived usability through the System Usability Scale (SUS). The study contributes a validated prototype that provides a foundation for subsequent implementation and effectiveness testing in authentic Fashion Design learning environments.

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2. METHODS

This study employed a Research and Development (R&D) approach to develop and evaluate a gamified mobile learning prototype for Fashion Design Education. Within this research approach, Design Thinking served as the development framework, guiding the development process through five human-centered and iterative stages: empathize, define, ideate, prototype, and test (Bhatt & Chakrabarti, 2022). Product feasibility was subsequently evaluated through expert validation involving a material expert and a media expert, while perceived usability was assessed using the System Usability Scale (SUS) involving student participants. Accordingly, R&D provided the overall research approach, Design Thinking guided the development process, expert validation assessed product feasibility, and SUS measured perceived usability. The implementation of the five Design Thinking stages is described in the following sections.

2.1. Empathize

The empathize stage aimed to understand the learning challenges and expectations of users regarding style and look learning. Preliminary needs analysis was conducted through interviews with one course lecturer and 10 students selected from a total of 30 students enrolled in the relevant course. The interviews focused on existing learning experiences, difficulties in understanding style and look concepts, preferred learning activities, and expectations regarding interactive learning media. The information gathered from these interviews was examined to identify recurring learning needs and expectations. A literature review was also conducted to complement the interview findings and provide a basis for determining relevant instructional and media requirements.

Table 1. Mapping of identified learning needs to FashionSim design features.

Identified need	Evidence from users	Design response
Visual exploration	Need for visual references to understand style and look concepts.	Style and look learning materials
Interactive practice	Need for activities to explore fashion combinations.	Mix-and-match activities
Progressive learning	Need for structured and gradual learning activities.	Four learning levels (Level 1–4)
Feedback and application	Need for assessment and opportunities to apply learned concepts.	Scoring, retry, and design challenges

Source: Research Documentation.

The identified needs were subsequently translated into specific design decisions for FashionSim. Visual exploration was addressed through structured learning materials on style and look, while the need for interactive application was accommodated through mix-and-match activities and theme-based design challenges. Progressive learning was implemented through four learning levels, supported by scoring, retry, and achievement features. These design decisions established the connection between the needs identified during the empathize stage and the instructional and gamification features developed during the subsequent stages.

2.2. Define

In the define stage, information obtained from the interviews and literature review was examined to identify the main learning needs and formulate the central design problem. The analysis indicated the need for more accessible and interactive learning experiences that enable students to explore style and look concepts, practice fashion combinations, engage in progressive learning activities, and receive feedback. Based on these findings, the problem was formulated through the following How Might We (HMW) statement: *"How might we enable Fashion Design students to explore style and look*

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concepts through interactive and progressive mobile learning activities?" This statement served as the foundation for translating the identified learning needs into specific product requirements, including structured learning materials, four progressive learning levels, mix-and-match activities, game challenges, points, achievements, and interactive assessments.

2.3. Ideate

During the ideate stage, the identified requirements were translated into concepts for the learning experience, content organization, user interaction, and gamification mechanisms. As illustrated in Figure 1, the identified learning needs were grouped into four main design clusters: visual exploration, progressive learning, interactive practice, and feedback and motivation. These clusters provided the basis for determining the proposed features in relation to their relevance to style and look learning and their ability to support progressive learning activities. The selected concept was then organized into a user flow and information architecture to establish the relationships between learning content, game activities, navigation, and user interaction. This process provided the design basis for the development of the FashionSim prototype.

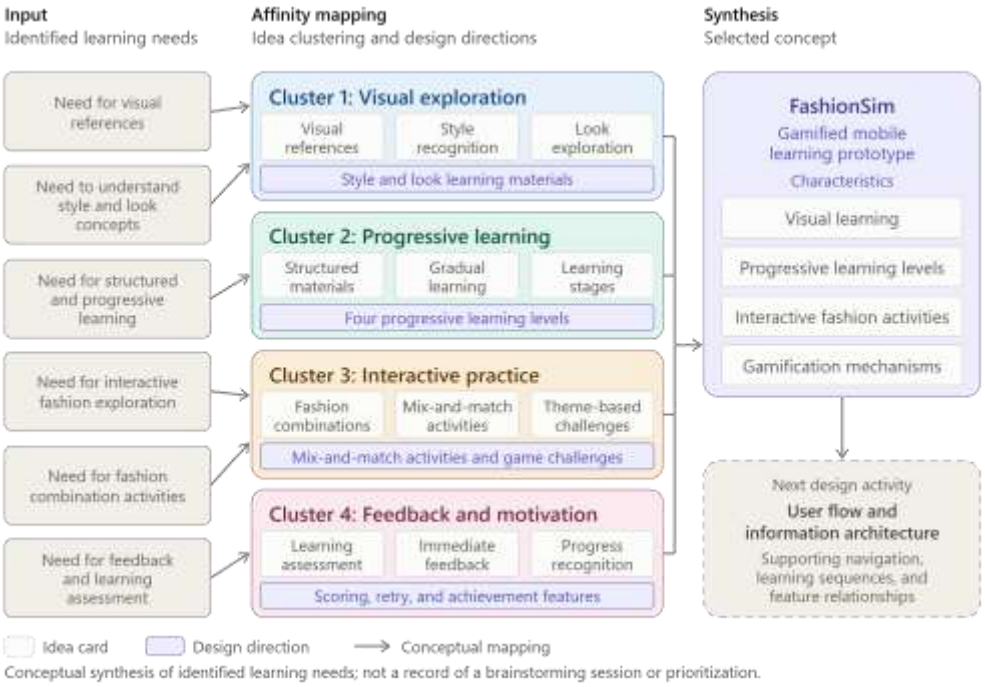


Figure 1. Affinity mapping of identified learning needs into design clusters for the FashionSim prototype.
Source: Research Documentation

2.4. Prototype

The prototype stage involved developing wireframes, user interfaces, visual assets, and an interactive mobile learning prototype using Figma. The prototype was designed to simulate the intended navigation structure, learning activities, gamification mechanisms, and user interaction patterns. Its main features included structured learning materials, four progressive learning levels, game challenges, mix-and-match activities, achievement features, and interactive assessments. Through Figma, users could navigate between screens and interact with the simulated learning activities to experience the proposed learning flow. However, the prototype represented a high-fidelity visual and interaction model rather than a fully operational mobile application.

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Therefore, aspects such as actual application performance, database integration, device compatibility, and runtime behavior were beyond the scope of this development stage.

2.5. Test

The test stage consisted of expert validation, prototype refinement, and student-based usability testing. Two experts were involved: one material expert who assessed the learning content and pedagogical components, and one media expert who evaluated the interface, visual presentation, navigation, and interactivity. Feedback from both experts was used to refine the prototype, as summarized in Table 2. The revised prototype was subsequently tested with 30 students using the System Usability Scale (SUS) to assess its perceived usability (Vlachogianni & Tselios, 2022).

Table 2. Expert feedback and prototype revisions.

Validator	Feedback / Identified Issue	Revision and Final Design
Material Expert	Learning content and pedagogical components required improvement.	Learning materials and instructional structure were refined.
Media Expert	Interface, visual presentation, navigation, and interactivity required improvement.	Interface and interaction design were refined.

Source: Research Documentation.

2.6. Research Procedure and Data Analysis

The overall research procedure is presented in Figure 2.

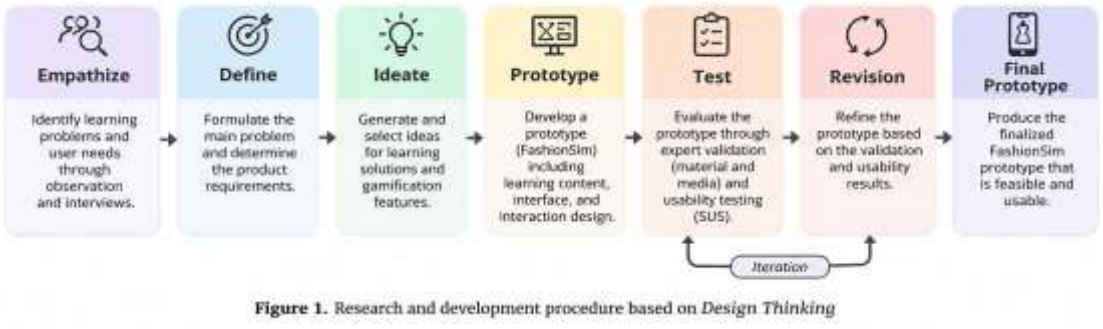


Figure 2. Research flow of the development and validation of the gamified mobile learning prototype.

Source: Research Documentation

The research data consisted of qualitative and quantitative data. Qualitative data obtained during the needs-identification stages were used to formulate the product requirements and guide prototype development. Quantitative data obtained from expert validation and usability testing were used to evaluate the developed product. Expert validation data were analyzed descriptively by calculating the percentage of the obtained score against the maximum possible score:

$$P = \frac{\sum X}{\sum X_{\max}} \times 100\% \quad (1)$$

where P is the feasibility percentage, $\sum X$ is the total score obtained, and $\sum X_{\max}$ is the maximum possible score. The resulting percentage was interpreted according to the feasibility criteria established in the research instrument.

Usability data were analyzed using the standard SUS scoring procedure. For the ten SUS items, scores from odd-numbered items were calculated by subtracting 1 from the original response, while scores from even-numbered items were calculated by subtracting the response from 5. The adjusted scores were summed and multiplied by 2.5, producing a final SUS score ranging from 0 to 100. The resulting score was interpreted using SUS acceptability, adjective-rating, and grade classifications.

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3. RESULTS AND DISCUSSION

3.1. Developed Prototype

The developed product, named FashionSim, is a gamified mobile learning prototype designed to support the learning of style and look concepts in Fashion Design Education. The prototype integrates structured learning materials with interactive activities to provide students with opportunities to explore fashion styles, understand fashion looks, and practice outfit composition. Its main features include learning materials, progressive learning levels, game challenges, mix-and-match activities, quizzes, points, achievements, and retry functions. The interface and main features of FashionSim are presented in Figure 3.



Figure 3. Representative user interfaces and gamification features of the developed prototype.
Source: Research Documentation

FashionSim was designed as a gamified mobile learning prototype rather than a standalone educational game. The instructional content remains the primary component of the learning experience, while selected game design elements are incorporated to organize students' learning activities and interactions. These elements include progressive levels, points, challenges, achievements, feedback, and retry functions. In this design, gamification functions as a mechanism for structuring the learning experience rather than replacing the instructional content.

The learning activities are organized into four progressive levels. Each level focuses on a specific aspect of fashion learning and is associated with an intended instructional objective. The sequence moves from the recognition of fashion styles to contextual understanding, visual composition, and theme-based design decision-making. The

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relationship between each level, its learning focus, activities, and intended learning objectives is presented in Table 3.

Table 3. Learning levels and intended learning objectives in FashionSim.

Level	Learning Focus	Learning Activity	Intended Learning Objective
Level 1	Style Recognition	Identifying the characteristics of different fashion styles through visual examples.	Students are able to identify characteristics of different fashion styles based on visual attributes.
Level 2	Look and Context	Associating fashion looks with relevant contexts by examining their visual characteristics and contextual elements.	Students are able to associate fashion looks with relevant contexts based on visual characteristics and contextual elements.
Level 3	Mix and Match	Selecting and combining fashion items to create an outfit.	Students are able to select and combine fashion items to create a visually coherent outfit.
Level 4	Theme-Based Design Challenge	Composing an outfit by selecting and coordinating fashion items according to a specified theme.	Students are able to compose an outfit that corresponds to a specified theme by selecting and coordinating appropriate fashion elements.

Source: Research Documentation.

As presented in Table 3, the four levels establish a progressive learning sequence, beginning with conceptual identification, followed by contextual understanding, visual composition, and theme-based design decision-making. This progression is intended to connect the learning materials with increasingly complex visual tasks. The game challenges and mix-and-match activities provide opportunities for students to apply the concepts presented in the learning materials, while points, achievements, feedback, and retry functions are incorporated to structure interaction throughout the learning process. These features represent the intended instructional design of FashionSim and are not evidence of measured improvements in students' learning performance. Among these activities, the mix-and-match feature represents a distinctive component of FashionSim. It was designed to provide opportunities for students to explore visual composition by combining clothing items, accessories, colors, materials, and silhouettes. This activity relates to several learning constructs relevant to Fashion Design Education, particularly visual composition, style recognition, contextual styling, and design decision-making. Through the combination of these fashion elements, students are expected to consider their visual relationships and suitability when composing a coherent outfit. Thus, the feature connects the conceptual understanding of fashion elements with their application in outfit composition.

To clarify the pedagogical alignment of the prototype, the main FashionSim features were mapped against their intended learning objectives, associated learning activities, and expected learning outcomes. This mapping illustrates how individual features are connected to the learning of style and look concepts, as well as the competencies they are designed to support. Table 4 presents the relationship between the main features and their intended instructional contributions.

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Table 4. Alignment of FashionSim features with intended learning outcomes.

Feature	Learning Objective	Learning Activity	Expected Learning Outcome
Style Identification	Recognize characteristics of different fashion styles.	Visual identification and classification of fashion styles.	Conceptual understanding of fashion styles.
Mix-and-Match	Combine fashion elements to create visually coherent outfits.	Selecting and combining clothing items, accessories, colors, materials, and silhouettes.	Visual composition skills.
Design Challenge	Apply style and look concepts to a specified theme.	Creating theme-based outfit compositions.	Design decision-making.
Feedback and Retry	Identify and correct errors during learning activities.	Reviewing feedback and repeating activities when necessary.	Self-regulation in learning.

Source: Research Documentation.

As shown in Table 4, each feature was designed to support a specific aspect of the learning process. Style identification focuses on developing conceptual understanding, while mix-and-match provides opportunities to explore visual composition through the coordination of fashion elements. The design challenge extends these activities by requiring students to apply style and look concepts to a given theme. Meanwhile, feedback and retry functions were incorporated to support error recognition and self-regulated learning. This alignment demonstrates how the prototype connects its interactive features with the intended learning objectives and outcomes. These outcomes represent the intended contributions of the instructional design rather than measured learning gains in the present study.

The FashionSim prototype was developed using Figma to represent its interface, navigation structure, and interactive learning activities. The prototype enables users to explore the main features and simulate interactions across the learning levels. However, it represents an interactive design prototype rather than a fully operational mobile application. Consequently, actual application performance, database integration, and compatibility across mobile devices were beyond the scope of the present development stage.

3.2. Expert Validation

Expert validation was conducted to evaluate the feasibility of the FashionSim prototype in terms of its instructional content and digital media design. The assessment involved two experts: one material expert and one media expert. The material expert evaluated the relevance and quality of the learning content and its instructional components, while the media expert assessed the visual presentation, interface design, navigation, interaction, and gamification features of the prototype.

The expert validation instruments were developed based on relevant theoretical frameworks to ensure that the assessment indicators reflected the intended evaluation aspects. The material validation instrument was guided by the constructive alignment framework of Biggs and Tang (2011), supported by the instructional design principles of Gagné et al. (2005). These frameworks informed the assessment of learning objectives, content relevance, instructional organization, learning activities, and assessment components. Meanwhile, the media validation instrument drew on Mayer's Cognitive Theory of Multimedia Learning (2021), Nielsen's usability heuristics (1994), and Werbach and Hunter's gamification framework (2012). These theories informed the indicators for visual and multimedia presentation, interface design, navigation, interaction, and gamification elements. The theoretical indicators were adapted to the

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characteristics of FashionSim as an interactive mobile learning prototype developed using Figma.

The material validation instrument consisted of 18 assessment items covering five aspects: learning suitability (3 items), content feasibility (5 items), systematic presentation (4 items), language (3 items), and learning activities and evaluation (3 items). Both instruments employed a five-point rating scale, ranging from 1 (lowest rating) to 5 (highest rating). The distribution of assessment items in the material validation instrument is presented in Table 5.

Table 5. Material validation instrument.

Assessment Aspect	Number of Items
Learning suitability	3
Content feasibility	5
Systematic presentation	4
Language	3
Learning activities and evaluation	3
Total	18

Source: Research Documentation.

Based on the 18 assessment items and the five-point rating scale, the maximum possible score for the material validation instrument was 90. The feasibility percentage was calculated by dividing the score obtained from the material expert by the maximum possible score and multiplying the result by 100%. The calculation is expressed as follows:

$$P_m = \frac{f_m}{90} \times 100\% = \frac{82}{90} \times 100\% = 91\% \quad (2)$$

where (P_m) represents the material feasibility percentage and (f_m) represents the total score obtained from the material expert. The resulting material feasibility score was 91%, indicating that the instructional content and pedagogical components of the FashionSim prototype were categorized as highly feasible.

The media validation instrument consisted of 25 assessment items covering five aspects: interface design (5 items), visual and multimedia quality (5 items), multimedia principles (6 items), navigation and interaction (5 items), and gamification design (4 items). The distribution of assessment items in the media validation instrument is presented in Table 6.

Table 6. Media validation instrument.

Assessment Aspect	Number of Items
Interface design	5
Visual and multimedia quality	5
Multimedia principles	6
Navigation and interaction	5
Gamification design	4
Total	25

Source: Research Documentation.

Based on the 25 assessment items and the five-point rating scale, the maximum possible score for the media validation instrument was 125. The feasibility percentage was calculated by dividing the score obtained from the media expert by the maximum possible score and multiplying the result by 100%. The calculation is expressed as follows:

$$P_d = \frac{f_d}{125} \times 100\% = \frac{115}{125} \times 100\% = 92\% \quad (3)$$

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where (P_d) represents the media feasibility percentage and (f_d) represents the total score obtained from the media expert. The resulting media feasibility score was 92%, indicating that the visual presentation, interface design, navigation, interaction, and gamification components of the FashionSim prototype were categorized as highly feasible.

The feasibility percentages obtained from both assessments were interpreted using five assessment categories. The classification criteria are presented in Table 7.

Table 7. Feasibility assessment criteria.

Percentage Range	Feasibility Category
81–100%	Highly Feasible
61–80%	Feasible
41–60%	Moderately Feasible
21–40%	Less Feasible
0–20%	Not Feasible

Source: Arikunto (2009) in Ghaniy and Leksono (2023).

Based on these criteria, both the material and media validation results fell within the Highly Feasible category. To provide an overall assessment of the prototype, the two feasibility percentages were averaged. The expert validation results are presented in Table 8.

Table 8. Expert validation results.

Validation Aspect	Number of Validators	Number of Indicators	Obtained Score	Maximum Score	Feasibility (%)	Category
Material Validation	1	18	82	90	91%	Highly Feasible
Media Validation	1	25	115	125	92%	Highly Feasible
Overall Mean	2	43	–	–	91.5%	Highly Feasible

Source: Research Documentation.

The overall feasibility percentage was calculated by averaging the material and media validation scores, as expressed in the following equation:

$$\overline{P} = \frac{P_m + P_d}{2} = \frac{91\% + 92\%}{2} = 91.5\% \quad (4)$$

As presented in Table 8, the FashionSim prototype achieved an overall feasibility score of 91.50%, placing it in the Highly Feasible category. The material expert's assessment yielded a score of 91%, indicating that the instructional content and pedagogical components met the feasibility criteria. Meanwhile, the media expert's assessment yielded a score of 92%, demonstrating the feasibility of the prototype's visual design, interface, and interactive components. Figure 4 illustrates a comparison of the feasibility percentages obtained from the material and media expert assessments.

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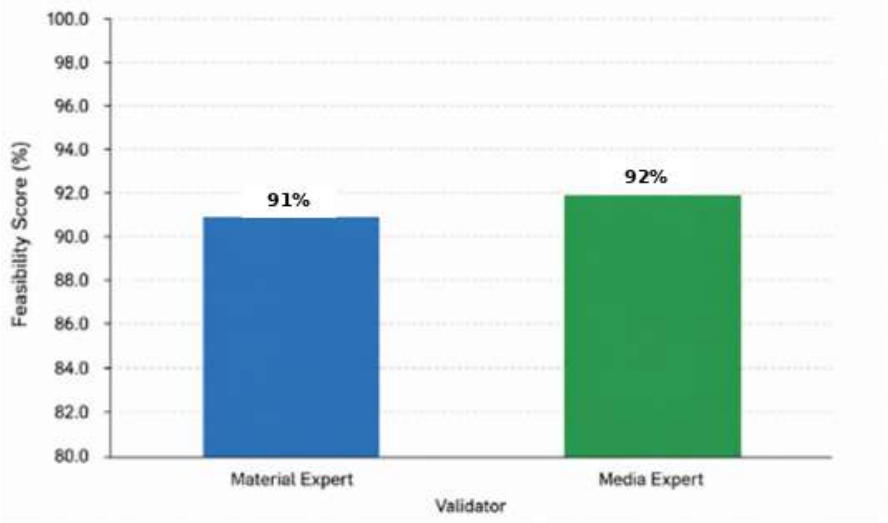


Figure 4. Comparison of expert validation scores.
Source: Research Documentation

The experts' assessments provided a basis for reviewing and refining the prototype before usability testing. The material validation focused on the instructional relevance and organization of the learning content, whereas the media validation focused on the presentation and interaction characteristics of the prototype. The feedback from both experts was considered in the refinement process to improve the prototype's instructional and media components. The revised prototype was subsequently evaluated by students through usability testing using the System Usability Scale (SUS).

3.3. Usability Testing

Following expert validation and subsequent prototype refinement, usability testing was conducted with 30 third-semester students from the Undergraduate Fashion Design Education Study Program. The participants represented the target users of FashionSim and had previously received introductory instruction on style and look concepts, providing them with relevant background knowledge to interact with the prototype. Participants were selected using purposive sampling from a population of approximately 60 students across two cohorts. The 30 students involved in usability testing belonged to the same participant group from which the 10 students for the preliminary needs analysis were selected during the empathize stage.

Usability was evaluated using the System Usability Scale (SUS), a standardized instrument for assessing users' perceived usability of a system. The responses were scored according to the standard SUS scoring procedure, and the resulting score was interpreted based on established usability classifications. The results of the usability evaluation, including the SUS score, acceptability level, and grade classification, are presented in Table 9.

Table 9. Usability testing results.

Measure	Result	Interpretation
SUS score	83.5	Excellent
Acceptability	Acceptable	Acceptable
Grade	A	Excellent usability

Source: Research Documentation.

Table 9 shows that the FashionSim prototype obtained a SUS score of 83.5, corresponding to an Excellent adjective rating, an Acceptable acceptability level, and a Grade A classification. These results indicate that the prototype demonstrated high perceived usability among the participating students.

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The usability findings complement the expert validation results by providing an assessment from the users' perspective. While expert validation examined the feasibility of the instructional content and media components, the SUS evaluation assessed students' perceived usability of the prototype. Taken together, these findings provide evidence of the prototype's feasibility and perceived usability. However, the SUS score reflects students' perceptions of their experience interacting with the prototype and does not measure learning gains, learning achievement, knowledge retention, design competence, or the quality of students' fashion-related decisions. Therefore, the SUS result should not be interpreted as evidence of the prototype's effectiveness in improving learning outcomes. Further research involving classroom implementation and appropriate learning assessments is needed to investigate these educational outcomes.

3.4. Discussion

3.4.1. Gamification as an Interactive Learning Strategy

The findings demonstrate that the integration of gamification into mobile learning can be adapted to the specific characteristics of Fashion Design Education. In the developed prototype, gamification elements are embedded within learning activities rather than functioning solely as visual or motivational features. Progressive levels were designed to organize the sequence of learning tasks, while game challenges and mix-and-match activities were intended to provide opportunities for learners to explore fashion concepts and practice outfit composition. This configuration is consistent with recent research showing that the educational contribution of gamification is influenced by the selection, combination, and instructional integration of game elements (Zeng et al., 2024).

The use of progressive levels is particularly relevant to Fashion Design learning because design competence develops through the gradual integration of conceptual knowledge and practical decision-making. In this prototype, learners are not immediately confronted with complex outfit composition; instead, activities progress from understanding style and look toward combining fashion elements and completing design challenges. This progression was designed to give gamification an instructional function by structuring the intended learning pathway (Dai et al., 2025). This design is consistent with previous research suggesting that the contribution of gamification depends not simply on the presence of game elements, but also on how those elements are combined and aligned with intended learning outcomes.

The mix-and-match feature further distinguishes the prototype from mobile learning media that primarily function as repositories of instructional content. By allowing learners to combine fashion items visually, the activity was designed to provide opportunities for applying concepts through experimentation and visual decision-making. This characteristic is particularly appropriate for Fashion Design Education, where learning involves the relationship between visual elements and the construction of a coherent appearance (Yusuf et al., 2021). The finding also extends existing research on mobile learning in Fashion Design, which has demonstrated the potential of mobile applications to support specific instructional activities such as pattern teaching (Xu et al., 2025).

3.4.2. Design Thinking as a Human-Centered Development Approach

The development process also demonstrates the relevance of Design Thinking for translating learner needs into concrete features of educational technology. Rather than beginning with technological features alone, the process started by identifying learning problems and user requirements and subsequently translated these findings into the

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learning structure, interaction model, and gamification mechanisms. This is consistent with the human-centered orientation of Design Thinking, in which understanding users and iteratively developing solutions are central to the design process (Siricharoen, 2023).

The resulting prototype illustrates how user requirements can be translated into specific product characteristics. The identified need for visual exploration was translated into mix-and-match activities, the need for progressive learning was reflected in level-based activities, and the need for feedback informed the inclusion of scoring, achievement indicators, level completion, and retry mechanisms. Thus, Design Thinking in this study functions not merely as a procedural framework but as a mechanism for connecting identified learning needs with product decisions.

This finding is important because educational technology development can become overly technology-driven when product features are determined primarily by available technological capabilities. The present approach instead positions learner needs as the basis for determining the interaction and gamification structure. Previous research has also highlighted the relevance of Design Thinking in educational innovation, particularly in developing solutions around users' needs and learning contexts (Aris et al., 2025).

3.4.3. Product Feasibility and Usability

The expert validation results demonstrate a balanced relationship between instructional and media quality. The material expert assessment reached 91.00%, while the media expert assessment reached 92%, resulting in an overall feasibility score of 91.50%. Both assessments were categorized as highly feasible. The relatively small difference between the two scores suggests that the prototype achieved comparable quality in its instructional content and media implementation.

From an instructional perspective, the high material validation score indicates that the learning content and pedagogical components were considered appropriate for the intended learning objectives. From a media perspective, the slightly higher score obtained from the media expert indicates that the visual interface, navigation, interactivity, and functional components were also considered appropriate. The consistency between these two assessments is particularly relevant for mobile learning because instructional quality alone is insufficient if the interface does not adequately support interaction with the learning content.

The usability testing provides an additional perspective on the prototype's quality from the users' standpoint. The prototype achieved a SUS score of 83.5, classified as Excellent, Acceptable, and Grade A. The result indicates that the prototype was perceived positively in terms of usability by its target users. This complements the expert validation because feasibility and usability represent different dimensions of product quality. Expert validation evaluates whether the product is appropriately designed from instructional and media perspectives, whereas usability testing examines whether users can interact with the resulting product satisfactorily. The use of the System Usability Scale (SUS) as a standardized instrument for evaluating the perceived usability of educational technology is supported by previous research (Vlachogianni & Tselios, 2022).

3.4.4. Contribution and Research Limitations

Taken together, the findings position FashionSim as a gamified mobile learning prototype with evidence of feasibility and perceived usability for Fashion Design Education. The contributions of this study can be identified in three aspects. First, its design contribution lies in translating identified learning needs in Fashion Design Education into interactive mobile learning features, including structured learning materials, progressive levels, mix-and-match activities, and theme-based design

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challenges. These features connect the learning of style and look concepts with interactive activities relevant to fashion learning contexts. Second, its pedagogical contribution lies in integrating progressive learning activities with visual exploration and decision-making. The learning sequence moves from identifying fashion styles and understanding their contexts to composing outfits and responding to theme-based design challenges. This structure provides an instructional framework that connects conceptual understanding with visual application in fashion learning. Third, its development contribution lies in providing a FashionSim prototype developed through a human-centered Design Thinking framework and evaluated through expert validation and student usability testing. The resulting evidence of feasibility and perceived usability provides a basis for further development and subsequent investigation of its educational effectiveness.

Nevertheless, the findings should be interpreted within the scope of the present development and evaluation study. The expert validation and SUS results provide evidence regarding product feasibility and students' perceived usability, rather than learning effectiveness. The study has not yet examined learning gains, knowledge retention, or the transfer of acquired knowledge and skills to other design contexts. Future research may implement FashionSim in authentic Fashion Design learning environments and investigate its educational contribution through appropriate learning assessments, particularly in relation to students' conceptual understanding of style and look, visual composition skills, and fashion-related design decision-making.

4. CONCLUSION

This study developed a gamified mobile learning prototype for Fashion Design Education using a Design Thinking approach to support the learning of style and look concepts. The resulting prototype integrates structured learning materials, progressive learning levels, game challenges, mix-and-match activities, points, achievements, and interactive assessments within a mobile learning environment. Based on expert assessment and student usability testing, FashionSim represents a prototype with evidence of feasibility and perceived usability. These findings provide a foundation for further development and implementation of gamified mobile learning in Fashion Design Education. Future research may explore its application in actual learning environments and examine its potential contribution to students' learning experiences and educational outcomes.

5. AUTHORS' NOTE

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