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User Interface Design for Gamification of Ethnomathematics Data/Content Based on Challenges of Local Wisdom

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Abstract

Not all students possess the capability to effectively solve problems in accordance with the materials they have studied, both theoretically and practically, in reference to the realities of everyday life. This phenomenon is particularly evident in many junior high schools in Bali, especially within the context of mathematics education. Consequently, there is a pressing need for innovative breakthroughs to address these challenges. One such approach involves the development of gamified mathematics learning based on local Balinese wisdom. The primary objective of this research is to demonstrate the design of a user interface for gamified ethnomathematics data/content grounded in the challenges of local Balinese wisdom. This research adopts a development approach, employing the Borg and Gall model, which focuses solely on the stages of design development, initial testing, and revisions based on the outcomes of the initial trials. The subjects involved in the initial testing of the user interface design include two informatics experts, two education specialists, 40 educational technology evaluators, and 20 public junior high school teachers in Bali, particularly from the southern region. Data collection tools utilized an instrument in the form of a questionnaire consisting of 15 items related to the design of the user interface for gamified ethnomathematics data/content based on the challenges of local Balinese wisdom. The analysis of the collected data employed quantitative descriptive techniques. The research findings indicate that the quality of the user interface design is within the 'good' category, with an average percentage of 87.19%. The contribution and the most obvious implications of this research is that it can clearly demonstrate the form of gamification user interface design. Design that contains aspects of game data/content that internalize the challenges of the reality of Balinese local wisdom so that it can improve students' critical thinking skills in solving complex problems of everyday life.

Keywords: User Interface Design, Gamification, Ethnomathematics Content, Reality Challenges, Local Wisdom.

1. Introduction

Students' success in comprehensively understanding materials through deep learning processes is evidenced by their ability to solve problems theoretically and practically, drawing on the realities of everyday life. Mathematics education at the junior secondary school level often encounters challenges related to enhancing students' problem-solving skills. One approach deemed effective in improving students' capabilities to tackle more complex problem-solving is ethnomathematics, which integrates culture and local wisdom into teaching mathematics. This approach renders the learning experience more contextual and aids students in comprehending the relevance of mathematics in their daily lives, particularly in relation to culture and local wisdom [1], [2], [3], [4].

The local wisdom of Bali, as one of the cultural heritages of the region, presents numerous mathematical concepts that can be explored, such as geometric patterns in traditional carvings, measurement systems used in customary ceremonies, and numerical concepts in traditional games. The integration of this local wisdom into mathematics education can enhance students' interest and motivation while simultaneously preserving local culture.

However, the reality on the ground is that many junior high school students in Bali are still unable to solve ethnomathematics problems based on the challenges of local Balinese wisdom. Therefore, there is a need for an innovative learning method that can be employed by junior high school students in Bali to acquire in-depth knowledge

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related to solving ethnomathematics problems rooted in the challenges of local Balinese wisdom. One innovative method/approach proposed is in the form of gamification of ethnomathematics data/content based on the realities of local balinese wisdom is utilized in education to incorporate elements of games into non-game contexts, thereby making learning more enjoyable while ensuring that the knowledge acquired by students is effectively conveyed through their direct actions in overcoming the challenges presented in the game [5], [6]. Gamification has been proven effective in enhancing student engagement, motivation, and learning outcomes [7], [8], [9]. By internalizing the concept of Balinese local wisdom within gamification, it is certain to create a more engaging and meaningful learning environment for students, thus enabling the assessment of junior high school students' (particularly in Bali) abilities in solving ethnomathematics problems to be conducted effectively.

Based on the issues and innovative ideas presented, the research problem formulated in this study is as follows: "How can the user interface design of gamified ethnomathematics data/content, based on real-world challenges of local Balinese wisdom, support the measurement of the problem-solving abilities of junior high school students in Bali in the context of ethnomathematics?"

Referring to the formulation of the problem, the objective of this research is to demonstrate the existence of a user interface design for gamified ethnomathematics data/content based on the challenges of local Balinese wisdom, which can facilitate developers' creation of a physical application in the future.

The presence of this research is motivated by the findings and limitations of several previous studies that require resolution. The study by Erita [10] focuses on developing an e-module for mathematics learning based on a scientific approach to assist the online learning process. The results of Erita's research indicate that, in general, the e-module for mathematics learning based on a scientific approach is practical for supporting online learning processes. However, the limitation of this research lies in the absence of a user interface design that illustrates the features of the e-module, particularly in packaging the materials with content and learning stages that can enhance students' abilities in solving complex problems, by addressing issues encountered in everyday life.

The research by Handikaningtyas et al. [11] demonstrates that implementing problem-based learning with a gamification approach is classified as effective in supporting meaningful learning experiences through activities relevant to the real world and can encourage students to participate actively in the learning process. A limitation of the study by Handikaningtyas et al. is that the stages of gamification have not been presented in depth and comprehensively to ensure that students can acquire knowledge and experience in solving complex problems. This is particularly pertinent concerning cultural issues and local wisdom, which are, in reality, also real-world problems frequently encountered in daily life.

The study by Gunawan et al. [12] illustrates that the efficacy of modules grounded in realistic mathematics education for improving students' mathematical connection skills is notably impressive. However, a limitation of Gunawan et al.'s study is the absence of content related to realistic mathematical materials that addresses issues concerning the integration of culture and local wisdom typically encountered in daily life.

The study by Tampubolon et al. [13] reveals the development of an interactive e-book for production unit courses, applying a hybrid learning system. A limitation of Tampubolon et al.'s research is that the interactive e-book they developed does not encompass materials that fosters students' abilities to solve complex problems related to issues found in everyday life.

Zhang et al. [14] indicate that open and interactive e-books significantly positively impact the learning process of Artificial Intelligence (AI) for K-12 students. However, a limitation of Zhang et al.'s research is that the developed open and interactive e-book does not contain AI materials. This AI content is essential for enhancing students' abilities to tackle complex problems related to real-life situations; nonetheless, the e-book developed only facilitates the formation of quality cognitive skills.

The research by Laksana et al. [15] illustrates that digital gamification and metacognitive skills significantly influence students' mathematical problem-solving abilities. A limitation of Laksana et al.'s study is the lack of evidence demonstrating a significant influence of digital gamification and metacognitive skills on problem-solving abilities related to culture and local wisdom within mathematics education.

Kadarisma et al. [16] demonstrate the high effectiveness of HTML5 flip technology in developing digital pocketbooks as innovative electronic books to enhance students' arithmetic skills. However, a limitation of Kadarisma et al.'s research is the absence of a user interface design that showcases features to accommodate materials that strengthens students' abilities to solve complex problems relevant to cultural and local wisdom issues encountered in daily life. The electronic book developed, therefore, focuses solely on numeracy or arithmetic skills.

Finally, the research by Choirudin et al. [17] indicates an improvement in high school students' mathematical problem-solving skills through interactive media based on gamification. Nevertheless, a limitation of Choirudin et al.'s study is the lack of demonstrated improvement in mathematical problem-solving skills specifically related to culture and local wisdom, as it is confined to general mathematical problems aligned with the prevailing national curriculum.

2. Method

2.1. Research Approach

This research employs a development approach. The development model utilized to produce the user interface design in this study is Borg and Gall, which focuses on three stages. The stages in question are: 1) design development; 2) initial testing; and 3) revisions based on the results of the initial testing [18], [19], [20], [21], [22], [23], [24], [25], [26]. Figure 1 illustrates the stages of the research in 2025 that aim to produce the user interface design.

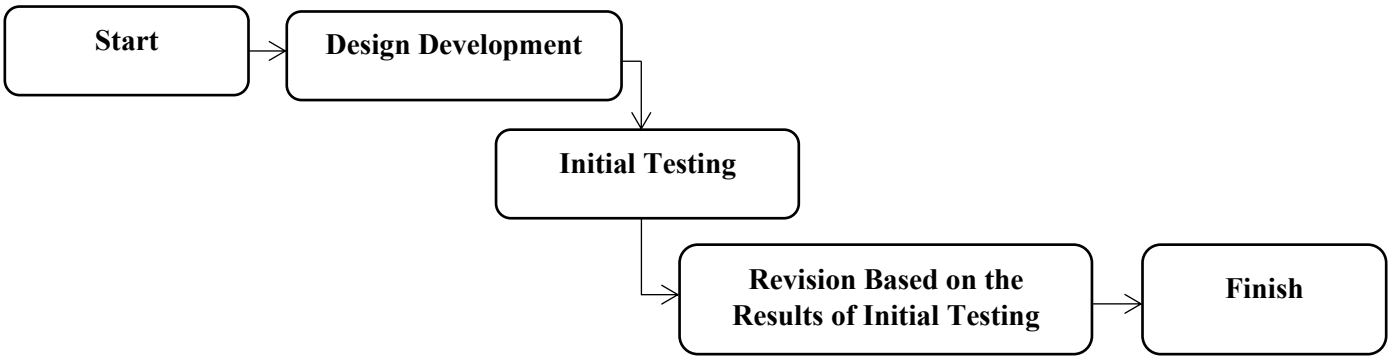

Figure 1. Stages of Development in the User Interface Design for Gamified Etnomathematics Content Based on Challenges of Local Wisdom in Bali

The reason for focusing on these three development stages is because the research product produced for 2025 is limited to producing user interface designs. However, other stages, such as field trials, revision of field trials, trial use, final product revision, and dissemination and implementation of the final product, will be conducted in 2026 because the research output will be gamification software ready for implementation.

2.2. Subjects, Object, and Location of Research

The subjects of this research were determined using a purposive sampling technique, whereby the subjects involved in the study were selected from the outset and were directly related to the design of the user interface for gamified ethnomathematics data/content based on the challenges of local wisdom in Bali. The criteria used in determining the parties to be sampled based on purposive sampling include: in-depth expertise in user interface design, in-depth expertise in ethnomathematics data/content, and in-depth understanding of the challenges of the reality of Balinese local wisdom. The subjects in this study included two experts in computer science, two educational specialists, 40 educational evaluators in information technology, and 20 public junior high school teachers in Bali, specifically in the southern region of Bali. These subjects were engaged in conducting preliminary trials on the research object. The object of this research is the design of the user interface for gamified ethnomathematics data/content based on the challenges of local wisdom in Bali. The study was conducted at public junior high schools in Bali, particularly in the southern Bali area, including Kuta, Nusa Dua, Jimbaran, Canggu, and South Denpasar. The reason for selecting the South Bali region for the research was to generalize the ideal conditions for implementing gamified ethnomathematics data/content at the junior high school level in Bali. This was confirmed by the researchers' observations of several junior high schools in South Bali. Several junior high schools in South Bali have demonstrated and implemented gamified ethnomathematics-based mathematics learning.

2.3. Data Collection Instruments

The data collection instrument employed in this research is a questionnaire. The questionnaire is utilized to obtain primary data from respondents in the form of quantitative information. This data serves as the foundation for decision-making concerning the quality level of the user interface design. The questionnaire used for the initial trial of the user interface design includes 15 items. The instrument's item validity was tested using the Pearson–product-moment correlation formula, while the instrument's item reliability was tested using the Cronbach's Alpha formula. The scores from the instrument's item validity and reliability tests were then compared with the Guilford scale for item categorization to determine the level of validity and reliability of the test items.

2.4. Data Analysis Techniques

The collected data were subsequently analyzed using quantitative descriptive techniques, employing descriptive percentage calculations. The results of these descriptive percentage calculations served as the foundation for interpreting the quality of the user interface design of the gamification of ethnomathematics data/content based on the challenges of local Balinese wisdom. The formula for the aforementioned descriptive percentage calculations is as follows [27], [28], [29], [30], [31], [32].

$$P = (f/N) \times 100\% \quad (1)$$

Notes:

P= the quality percentage; f = total acquisition value; N = maximum total value.

The percentage results obtained from the formula are subsequently converted into the following five-point categorization table [33], [34], [35], [36], [37]. The assessment scale used to measure the quality of respondents' perceptions of the user interface design of the ethnomathematics data/content gamification based on the challenges of Balinese local wisdom. The Likert scale consists of five scores: a score of 5 representing excellence, a score of 4 representing good, a score of 3 representing moderate, a score of 2 representing less, and a score of 1 representing poor. The quality percentages from 0-54 to 90-100 and follow-up (both revised and non-revised) shown in table 1 are based on the results of previous research which also has the same quality standards for measuring the quality of an object being studied [38], [39], [40].

Table 1. Quality Standard of Five's Scale

Category of Quality	Percentage of Quality (%)	Follow-up
Poor	0-54	Revision
Less	55-64	Revision
Moderate	65-79	Revision
Good	80-89	No Revision
Excellence	90-100	No Revision

3. Result and Discussion

3.1. Results

Several results have been obtained based on the research activities conducted in 2025, referring to the Borg and Gall model. These results include: 1) the initial form of the user interface design, 2) the outcomes of the initial trials, 3) recommendations for improvements, and 4) the revised form of the user interface design. The initial form of the user interface design for gamified ethnomathematics data/content was derived from the design development phase. The revised form of the user interface design for gamified ethnomathematics data/content was obtained from the revision phase based on the outcomes of the initial trials. The improvement suggestions provided by respondents during the initial trial phase informed the revision.

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3.1.1. Design Development Stage

At this stage, the initial design of the user interface for the gamification of ethnomathematics data/content based on challenges related to local Balinese wisdom has been developed. This design was created using the Balsamiq Mockup application. The complete view of the initial user interface design for the gamification of ethnomathematics data/content based on challenges related to local Balinese wisdom can be seen in figure 2.

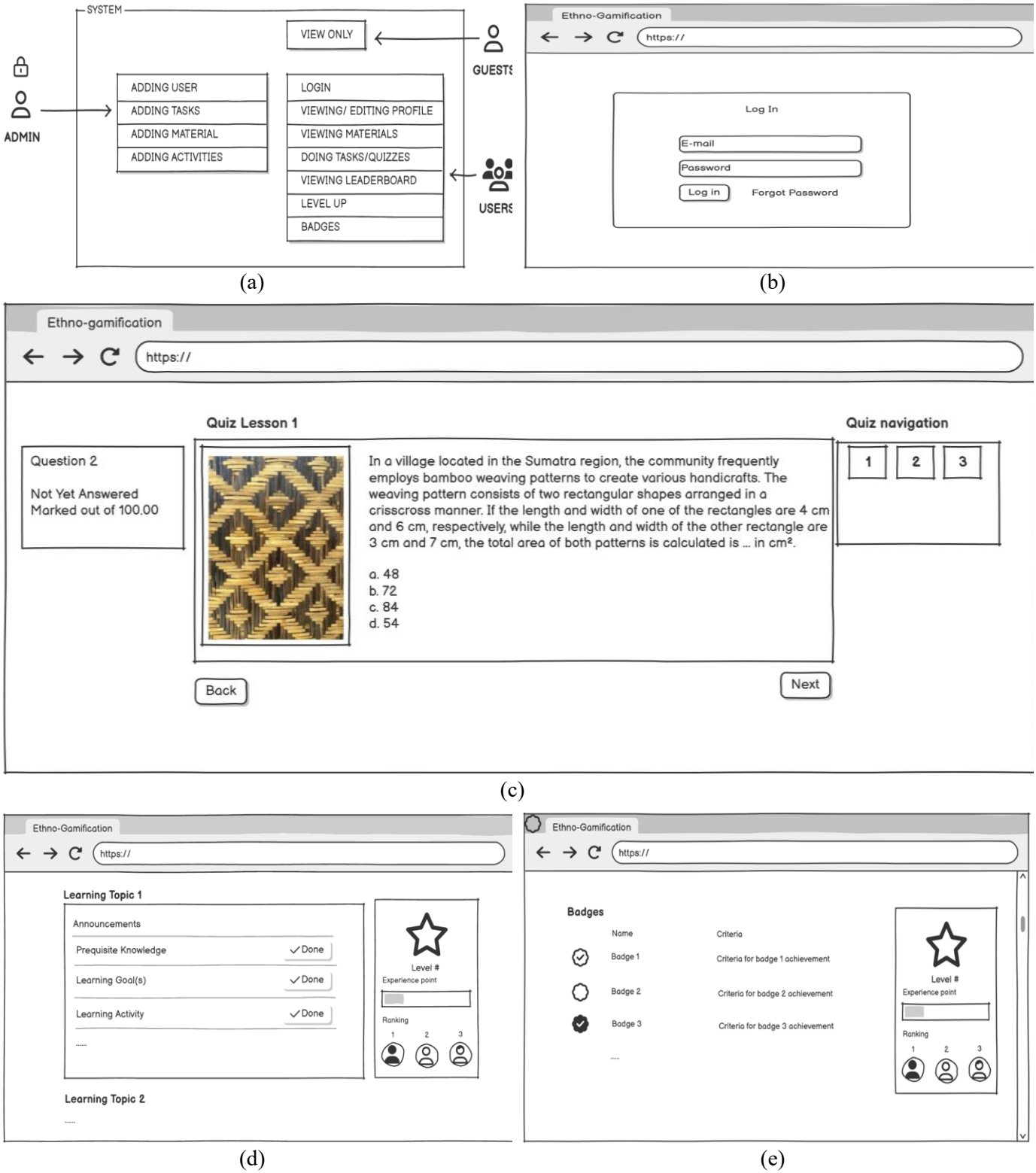

Figure 2. User Interface Design for the Gamification of Ethnomathematics Data/Content Based on Challenges Related to Local Balinese Wisdom

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Figure 2(a) illustrates the design of the main dashboard. This design incorporates features that facilitate user access to all facilities available within the gamification application for ethnomathematics based on the challenges of local wisdom in Bali. Access rights to each feature are tailored according to user categories. Administrators have access to several features, including adding users, tasks, materials, and activities. Users can access various features, including: logging in, editing profiles, viewing materials, completing tasks/quizzes, viewing the leaderboard, levelling up, and earning badges. Guests are limited to accessing view-only features. Figure 2(b) illustrates the user interface design employed by users to enter their email and password to log into the application. This design features two textboxes and one button. One textbox is designated for email input, another for password input, and a single button to facilitate the login process. There's a "Forgot Password" text link to guide users if they forget their email or password. This allows them to access the app again by first receiving a link to repair/reset their email and password. Passwords must be at least 8 characters long, must contain an initial capital letter, and must contain at least one of the following symbols: $%#@and!*.

Figure 2(c) illustrates the user interface design employed by users for activities such as quizzes, examinations, or practice questions that support the gamification of ethnomathematics data/content based on the challenges of local Balinese wisdom. This design describes the quiz, examination, or practice questions. Additionally, it includes a navigation feature for the items that have been answered or remain unanswered by the user. Figure 2(d) illustrates the user interface design users employ to view learning topics and engage in learning activities. Each learning materials included: prior knowledge, learning objectives, learning activities, and other related tasks. The confirmation mark on the right indicates that the student has completed the activity. Additionally, the right-hand block displays the level based on the student's achievements during the learning process, accompanied by a progress bar. The user interface design also features the ranking of students who excel in learning. Figure 2(e) depicts the user interface design users utilize to view the badges they earned after successfully completing the learning process. This design presents badges to showcase high-achieving students' top three ranking names. This design also displays the criteria met, affirming that the three top-ranking names deserve recognition for their achievements. This design also shows fair ranking according to student learning outcomes, in order to avoid excessive competition.

3.1.2. Initial Testing Stage

The initial testing phase of the user interface design for the gamification of ethnomathematics content, based on the challenges of local wisdom in Bali, was conducted following the formation of the design. This trial was carried out by two experts in informatics, two education specialists, 40 IT education evaluators, and 20 teachers from state junior high schools in Bali, specifically in South Bali. The results of the initial trials can be seen in tables 2 to 4. Recapitulation of initial trial results conducted by experts, evaluators, and teachers can be seen ini table 5.

Table 2. Results of Initial Trials Conducted by Experts on the User Interface Design of Gamification of Ethnomathematics Data/Content Based on the Challenges of Balinese Local Wisdom Reality

Respondents	Items-															∑	Percentage of Quality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Education Expert-1	5	5	5	4	4	4	4	4	5	5	5	4	4	5	4	67	89.33
Informatics Expert-1	5	4	4	4	4	5	5	4	4	4	4	5	4	4	5	65	86.67
Education Expert-2	4	5	4	5	5	5	4	4	5	5	4	4	5	4	5	68	90.67
Informatics Expert-2	4	4	4	5	4	4	5	5	5	4	4	5	4	4	4	65	86.67
																Average	**88.33**

Table 2 presents the initial trial results obtained from four respondents regarding the user interface design. The four respondents were two education experts and two informatics experts. Fifteen questions were used to obtain a significance rating score given by the experts. The average quality percentage was 88.33%, indicating that the user interface design of gamification of ethnomathematics data/content based on the challenges of Balinese local wisdom reality is classified as good quality.

Table 3 presents the initial trial results obtained from 40 respondents regarding the user interface design. All 40 respondents were evaluators in the education sector. Fifteen questions were used to obtain a significance rating score

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given by the education evaluators. The average quality percentage was 87.37%, indicating that the user interface design of gamification of ethnomathematics data/content based on the challenges of Balinese local wisdom reality is classified as good quality.

Table 3. Results of Initial Trials Conducted by Evaluators on the User Interface Design of Gamification of Ethnomathematics Data/Content Based on the Challenges of Balinese Local Wisdom Reality

Respondents	Items-															∑	Percentage of Quality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Evaluator-1	4	5	4	4	5	4	4	4	4	4	4	4	5	4	5	64	85.33
Evaluator-2	5	5	5	4	4	4	5	5	4	4	5	4	4	5	4	67	89.33
Evaluator-3	4	5	5	4	5	5	4	4	4	5	4	4	4	5	4	66	88.00
Evaluator-4	5	5	4	4	5	5	4	5	4	4	5	5	4	5	5	69	92.00
Evaluator-5	4	4	5	4	4	4	5	5	5	5	5	4	4	5	5	68	90.67
Evaluator-6	5	4	4	5	4	4	4	4	4	4	4	5	4	4	4	63	84.00
Evaluator-7	4	4	5	4	4	4	5	4	5	5	4	4	5	4	4	65	86.67
Evaluator-8	4	5	5	4	5	5	4	4	4	4	4	5	4	4	4	65	86.67
Evaluator-9	5	5	4	4	5	5	4	5	5	4	4	4	5	5	4	68	90.67
Evaluator-10	4	4	5	4	4	4	4	5	5	5	4	4	5	5	5	67	89.33
Evaluator-11	5	4	4	5	4	4	4	4	4	4	5	4	4	4	5	64	85.33
Evaluator-12	4	4	5	4	4	4	5	4	4	5	4	5	4	4	4	64	85.33
Evaluator-13	4	4	5	4	4	4	4	4	4	4	5	5	4	4	4	63	84.00
Evaluator-14	5	4	4	5	4	4	4	4	4	4	5	5	4	4	5	65	86.67
Evaluator-15	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	62	82.67
Evaluator-16	4	5	4	5	5	5	5	5	5	5	4	4	4	4	4	68	90.67
Evaluator-17	4	4	4	5	4	4	5	4	4	4	4	4	5	4	5	64	85.33
Evaluator-18	4	5	4	4	5	4	4	5	4	4	4	4	4	5	5	65	86.67
Evaluator-19	5	5	5	4	4	4	4	4	4	5	5	5	4	5	4	67	89.33
Evaluator-20	4	5	5	4	5	5	4	5	5	4	5	5	4	5	4	69	92.00
Evaluator-21	5	5	4	4	5	5	4	5	5	4	5	4	4	5	5	69	92.00
Evaluator-22	4	4	5	4	4	4	4	4	4	4	4	4	5	4	4	62	82.67
Evaluator-23	5	4	4	5	4	4	5	4	5	4	4	4	5	5	5	67	89.33
Evaluator-24	4	4	5	4	4	4	4	5	5	5	5	4	5	4	4	66	88.00
Evaluator-25	4	5	5	4	5	5	4	5	4	4	4	4	4	5	4	66	88.00
Evaluator-26	5	5	4	4	5	5	4	5	4	4	4	5	4	4	4	66	88.00
Evaluator-27	4	5	4	4	5	4	4	4	4	4	4	4	5	5	5	65	86.67
Evaluator-28	4	4	4	4	4	4	5	5	4	4	4	5	5	5	4	65	86.67
Evaluator-29	4	5	4	4	4	5	5	5	5	5	4	5	4	5	4	68	90.67
Evaluator-30	5	5	5	5	4	5	4	4	4	4	4	4	5	4	4	66	88.00
Evaluator-31	5	4	4	4	4	4	5	4	4	4	5	4	4	4	4	63	84.00
Evaluator-32	5	4	4	4	5	4	4	5	4	4	4	4	5	4	4	64	85.33
Evaluator-33	5	5	4	4	4	4	5	4	4	4	5	5	5	4	5	67	89.33

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Respondents	Items-															∑	Percentage of Quality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Evaluator-34	4	4	4	4	5	5	5	4	5	4	5	5	5	5	4	68	90.67
Evaluator-35	5	4	5	4	5	5	5	4	5	4	4	4	4	4	5	67	89.33
Evaluator-36	4	4	5	4	4	4	4	4	4	5	4	4	4	4	4	62	82.67
Evaluator-37	5	4	4	5	4	4	4	4	5	4	4	4	4	4	5	64	85.33
Evaluator-38	5	5	4	4	4	5	4	5	5	5	4	4	4	4	5	67	89.33
Evaluator-39	4	4	4	4	5	5	5	5	4	4	4	4	4	4	4	64	85.33
Evaluator-40	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5	62	82.67
																Average	**87.37**

Table 4 presents the initial trial results obtained from 20 respondents regarding the user interface design. All 20 respondents were public junior high school teachers in Bali (specifically South Bali). Fifteen questions were used to obtain a significance rating score given by the teachers. The average quality percentage was 85.87%, indicating that the user interface design of gamification of ethnomathematics data/content based on the challenges of Balinese local wisdom reality is classified as good quality.

Table 4. Results of Initial Trials Conducted by Teachers on the User Interface Design of Gamification of Ethnomathematics Data/Content Based on the Challenges of Balinese Local Wisdom Reality

Respondents	Items-															∑	Percentage of Quality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Teacher-1	4	4	4	4	5	4	4	4	5	5	4	4	4	5	5	65	86.67
Teacher-2	5	4	4	4	5	5	5	4	5	5	5	5	4	5	4	69	92.00
Teacher-3	5	5	5	4	4	4	4	4	4	4	4	4	4	4	5	64	85.33
Teacher-4	4	4	4	4	4	4	4	5	4	4	4	4	5	4	4	62	82.67
Teacher-5	4	4	4	5	5	4	4	4	5	4	4	4	5	4	5	65	86.67
Teacher-6	5	4	4	4	4	4	4	4	5	5	5	4	5	5	5	67	89.33
Teacher-7	4	4	4	5	4	5	5	4	4	4	4	4	4	5	5	65	86.67
Teacher-8	4	5	4	5	4	4	4	4	4	4	4	5	4	4	4	63	84.00
Teacher-9	4	5	4	4	4	4	4	5	5	4	4	4	5	4	4	64	85.33
Teacher-10	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5	62	82.67
Teacher-11	4	4	4	4	4	4	4	5	4	5	4	4	4	4	4	62	82.67
Teacher-12	5	4	4	4	5	5	4	4	4	4	5	4	4	4	5	65	86.67
Teacher-13	5	5	5	4	5	5	4	4	4	4	4	5	5	5	4	68	90.67
Teacher-14	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	60	80.00
Teacher-15	4	4	4	5	4	4	4	5	5	4	4	4	4	4	5	64	85.33
Teacher-16	5	4	4	4	4	4	4	5	5	4	5	5	4	4	4	65	86.67
Teacher-17	4	4	4	5	5	5	4	4	4	5	4	4	4	4	4	64	85.33
Teacher-18	4	5	4	5	5	4	5	4	4	4	5	4	5	4	4	66	88.00
Teacher-19	4	5	4	4	4	4	4	4	4	4	4	4	4	5	4	62	82.67
Teacher-20	4	4	5	4	4	4	5	5	5	5	4	4	4	4	5	66	88.00

Respondents	Items-															∑	Percentage of Quality (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
																Average	**85.87**

Table 5 presents a recapitulation of the initial trial results conducted by all respondents (experts, evaluators, and teachers). Overall, the quality of the user interface design fell into the good category, as evidenced by the percentage range of 80-89%. Table 1 clearly indicates that the 87.19% percentage falls within the good quality category.

Table 5. Recapitulation of Initial Trial Results Conducted by Experts, Evaluators, and Teachers

Respondents	Percentage of Quality (%)	Category of Quality
Experts	88.33	Good
Evaluators	87.37	Good
Teachers	85.87	Good
Average	**87.19**	**Good**

Respondents provided several suggestions during the initial testing of the user interface design for the gamification of ethnomathematics data/content based on real-life challenges related to local Balinese wisdom. These suggestions served as a foundation for subsequent revisions. Table 6 provides a comprehensive overview of the suggestions provided by the respondents.

Table 6. Suggestions from respondents for the enhancement of the User Interface Design of Gamified Ethnomathematics Data/Content Based on Real-World Challenges of Local Wisdom in Bali.

No.	Respondent	Suggestions
1	Education Expert-1	Please add the letter ‘s’ at the end of the word ‘material’ in the feature ‘adding material’ as illustrated in Figure 2(A) and show the pseudo code in mathematical notation.
2	Informatics Expert-1	Please enhance the features to incorporate gamification elements related to ethnomathematics, based on the challenges of local Balinese wisdom, into the learning topic form. The learning topic form allows you to enter learning topics for each class meeting.
3	Education Expert-2	It is necessary to incorporate an editing mode/facility to modify the learning content teachers within the learning topic form will provide.
4	Informatics Expert-2	It is necessary to enhance the facilities to enable the addition of questions to the quiz.
5	Evaluator-16	It is advisable to provide a feature that allows for the editing or updating quiz questions.
6	Evaluator-34	It is essential to demonstrate the facilities that can be utilized to incorporate gamification materials related to ethnomathematics, based on the challenges of local wisdom in Bali, into the learning framework of the topic.
7	Teacher-8	Add a feature to enable the randomisation of quiz question orders.
8	Teacher-14	Please create a feature to add quiz questions.

3.1.3. Revision Stage of Initial Trial Result

Based on the recommendations provided by Education Expert-1, improvements to the user interface design previously presented in figure 2(a) are necessary. The feature ‘adding material’ depicted in figure 2(a) should have the letter ‘s’ appended to the word material, rendering it as ‘adding materials’. The revised outcome concerning figure 2(a) can be observed in figure 3. The pseudo code can be seen in figure 4.

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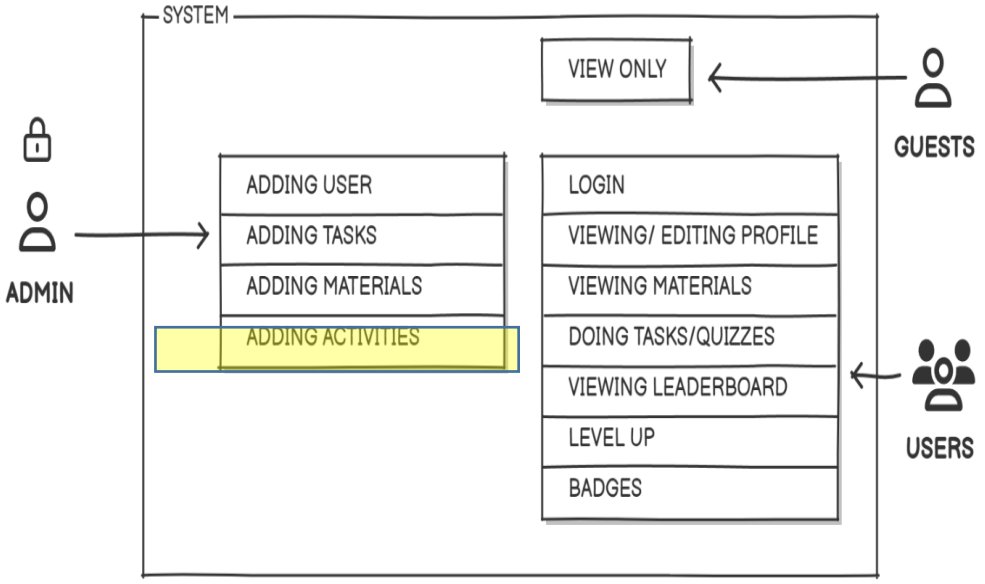

Figure 3. User Interface Design for Main Dashboard (After Revised)

Figure 3 illustrates the modifications made to the feature 'adding materials'. Initially, the term "material" was used without the letter ‘s’ at the end; however, following the revision, it was changed to "materials". This alteration can be observed in the yellow-highlighted block in figure 3.

Page 1

Pseudocode in Mathematical Notation

Let $\mathcal{S}$ be the system state, A be the set of actors $\{ \text{Admin}, \text{User}, \text{Guest} \}$, and $\mathcal{M}$ be the set of function modules $\{\text{AdminModule}, \text{UserModule}, \text{GuestModule}\}$.

1. *Module Definition as Sets of Functions*
   - A. *Admin Module ($\mathcal{M}_{\text{Admin}}$)*
     The set of functions callable by the Admin actor.
     $$\mathcal{M}_{\text{Admin}} = \{ f_{\text{AddUser}}, f_{\text{AddTask}}, f_{\text{AddMaterial}}, f_{\text{AddActivity}} \}$$
   - B. *User Module ($\mathcal{M}_{\text{User}}$)*
     The set of functions callable by an authenticated User actor.
     $$\mathcal{M}_{\text{User}} = \{ f_{\text{Login}}, f_{\text{ViewEditProfile}}, f_{\text{ViewMaterials}}, f_{\text{DoTasksQuizzes}}, f_{\text{ViewLeaderboard}}, f_{\text{LevelUp}}, f_{\text{AwardBadges}} \}$$
   - C. *Guest Module ($\mathcal{M}_{\text{Guest}}$)*
     The set of functions callable by the Guest actor.
     $$\mathcal{M}_{\text{Guest}} = \{ f_{\text{ViewOnly}} \}$$

2. *Definition of Key Functions*

Pseudocode Function	Mathematical Notation	Formal Description
Login(u, p)	$\text{Auth}(u, p) \to \{ \text{True}, \text{False} \}$	An Authentication function mapping username (u) and password (p) to a boolean success value.
AddUser()	$f_{\text{AddUser}} : \mathcal{S} \to \mathcal{S}'$	A function that modifies the system state ($\mathcal{S}$) by adding a new user.
ViewMaterials(id)	$f_{\text{ViewMaterials}}(u_{\text{id}})$	A function returning the set of learning materials accessible to user u_{id}.
DoTasksQuizzes(id, tid)	$f_{\text{DoTasksQuizzes}}(u_{\text{id}}, t_{\text{id}})$	A function that records the score and progress for user u_{id} on task/quiz t_{id}.

3. *Main System Flow Logic*
   The system operates in an infinite loop as long as the Running condition is true. Let I be the received input, and $\text{Source}(I) \in A$ be the actor source of that input.
   - A. *Admin Condition*
     If the input source is Admin, the system executes the admin function $f_{\text{AdminAction}}$ based on the action a:
     $$\text{IF } \text{Source}(I) = \text{Admin} \text{ THEN } \mathcal{S}' \leftarrow f_{\text{AdminAction}}(\mathcal{S})$$
     Where $f_{\text{AdminAction}}$ is defined conditionally (Case mapping):
     $$f_{\text{AdminAction}} = \begin{cases} f_{\text{AddUser}} & \text{if } a = \text{"ADD\_USER"} \\ f_{\text{AddTask}} & \text{if } a = \text{"ADD\_TASK"} \\ f_{\text{AddMaterial}} & \text{if } a = \text{"ADD\_MATERIAL"} \\ f_{\text{AddActivity}} & \text{if } a = \text{"ADD\_ACTIVITY"} \\ \dots & \text{otherwise} \end{cases}$$

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- B. *User Condition*
  If the input source is User, the system checks authentication. Let u and p be the entered credentials.
  1) Authentication:
     $$\text{IF } \text{Source}(I) = \text{User} \text{ AND } \text{Auth}(u, p) = \text{True} \text{ THEN } \dots$$
  2) User Action:
     If authentication is successful, the system executes the user function $f_{\text{UserAction}}$ based on the action a' and the authenticated user ID (u_{id}):
     $$\mathcal{S}' \leftarrow f_{\text{UserAction}}(\mathcal{S}, u_{\text{id}})$$
     Where $f_{\text{UserAction}}$ is:
     $$f_{\text{UserAction}}(u_{\text{id}}) = \begin{cases} f_{\text{ViewEditProfile}}(u_{\text{id}}) & \text{if } a' = \text{"VIEW\_EDIT\_PROFILE"} \\ f_{\text{ViewMaterials}}(u_{\text{id}}) & \text{if } a' = \text{"VIEW\_MATERIALS"} \\ f_{\text{DoTasksQuizzes}}(u_{\text{id}}, t_{\text{id}}) & \text{if } a' = \text{"DO\_TASKS\_QUIZZES"} \\ f_{\text{ViewLeaderboard}}(u_{\text{id}}) & \text{if } a' = \text{"VIEW\_LEADERBOARD"} \\ f_{\text{LevelUp}}(u_{\text{id}}) & \text{if } a' = \text{"LEVEL\_UP\_CHECK"} \\ f_{\text{AwardBadges}}(u_{\text{id}}, b_{\text{id}}) & \text{if } a' = \text{"AWARD\_BADGE\_CHECK"} \\ \dots & \text{otherwise} \end{cases}$$
  3) Failed Authentication:
     $$\text{ELSE IF } \text{Source}(I) = \text{User} \text{ AND } \text{Auth}(u, p) = \text{False} \text{ THEN } \text{Display}(\text{"Invalid credentials"})$$
- C. *Guest Condition*
  If the input source is Guest, the system executes the function f_{ViewOnly}: $$\text{ELSE IF } \text{Source}(I) = \text{Guest} \text{ THEN } \mathcal{S}' \leftarrow f_{\text{ViewOnly}}(\mathcal{S})$$
- D. *Unknown Condition*
  For any unknown input source:
  $$\text{ELSE } \text{Display}(\text{"Unknown input source"})$$

Figure 4. Pseudo Code in Mathematical Form of User Interface Design for Main Dashboard

Based on the recommendations provided by Informatics Expert-1 and Evaluator-34, it is necessary to implement improvements to the user interface design previously illustrated in figure 2(d). The learning topic feature within the learning topic form must be populated with gamified materials pertaining to ethnomathematics, grounded in the

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challenges of local Balinese wisdom. The changes made to figure 2(d), which show how to include gamified materials about ethnomathematics based on local Balinese wisdom, are shown in figure 5.

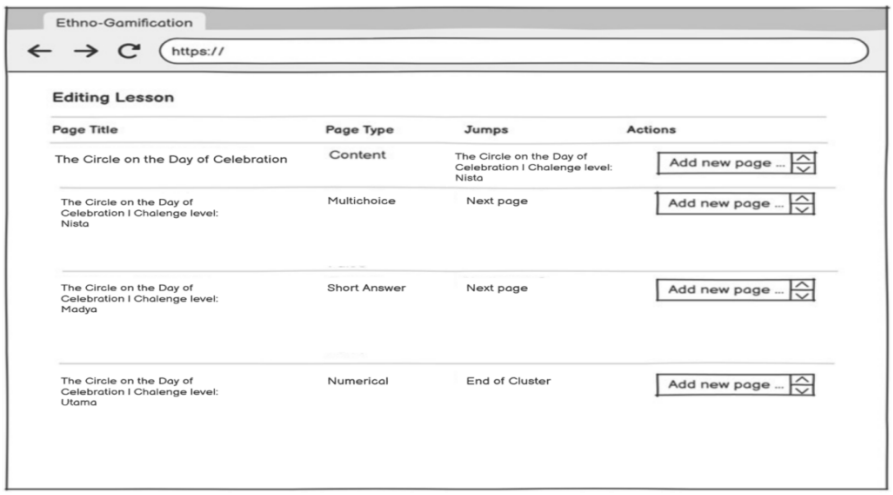

Figure 5. User Interface Design to Add Material Ethnomathematics Data/Content Based on Real-World Challenges of Local Wisdom in Bali

Figure 5 illustrates the design modifications that need to be implemented to facilitate teachers' incorporation of gamification material for ethnomathematics data/content based on local wisdom challenges of Bali into the learning topic form. This gamification includes three levels of challenges grounded in the local wisdom of Bali: Nista, Madya, and Utama. Nista serves as the foundation for creating challenges at an easy level. Madya serves as the basis for developing challenges at an intermediate level. Utama is a foundation for formulating challenges at the most difficult level.

Based on the recommendations provided by Education Expert-2, improvements to the user interface design previously illustrated in figure 2(d) must be implemented. The learning topic feature within the learning topic form must have an editing mode or facility to modify the educational content. The revised outcome about the editing mode of the academic content can be observed in figure 6.

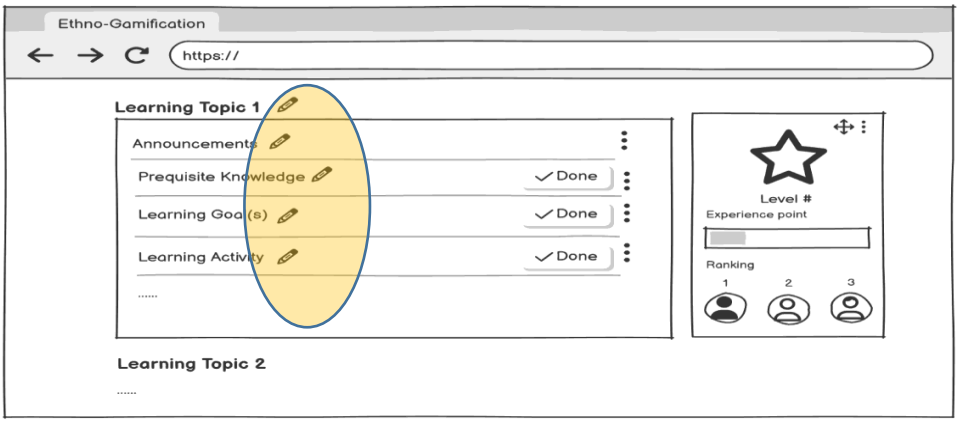

Figure 6. Design of User Interface for Editing Mode/Facilities for Modifying Learning Content

Figure 6 illustrates a design with an editing mode/facility for modifying learning content. This feature assists teachers in editing learning materials when challenges arise during implementation. The relevant features can be observed in the yellow block within figure 6.

Based on the recommendations provided by Informatics Expert-2, Evaluator-16, and Teacher-14, the user interface design previously presented in figure 2(c) must be improved. The quiz depicted in figure 2(d) requires adding facilities to enable the inclusion of new questions or updating existing quiz questions. The results of the revisions about adding new questions to the quiz and updating quiz questions can be observed in figure 7.

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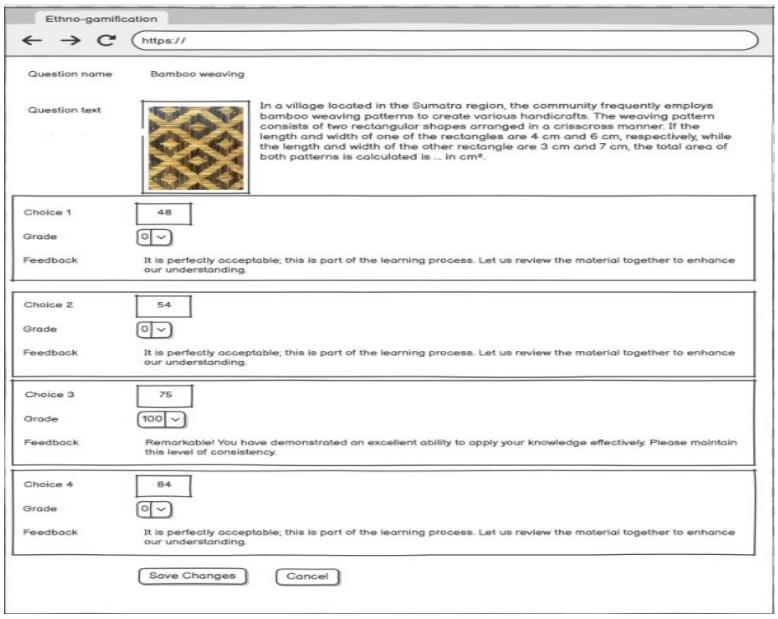

Figure 7. Design User Interface Add and Update Quiz Questions

Figure 7 illustrates a design incorporating features for adding new questions to a quiz and updating existing questions. This design includes facilities for inputting new questions, choices, grades, and a save button. Furthermore, the design also displays the grading settings and answer keys for each question.

Based on Teacher-8's recommendations, the user interface design previously presented in figure 2(c) must be enhanced. The quiz depicted in figure 2(c) requires configuring its sequence to ensure randomness. The design of the user interface for randomising the order of quiz questions can be observed in figure 8.

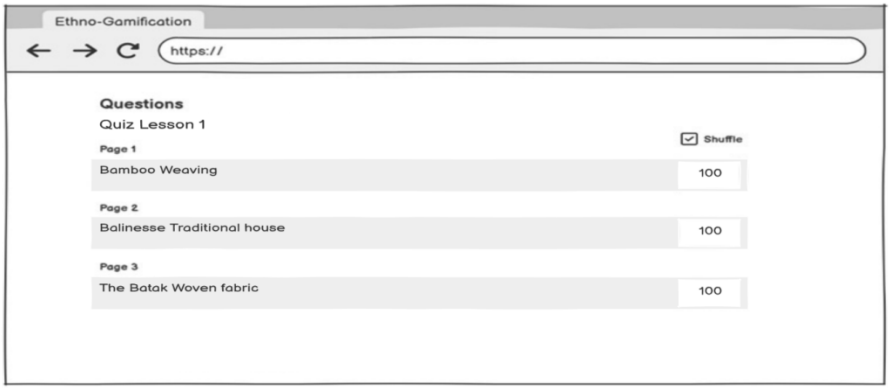

Figure 8. Designing a User Interface for a Facility to Randomise the Sequence of Quiz Questions

Figure 8 illustrates a design incorporating a feature for randomising the order of quiz questions. Within this design, there is a checkbox labelled "shuffle". This shuffle facility serves the purpose of processing the randomisation of the sequence of each quiz question.

3.2. Discussion

The user interface design quality of the ethnomathematics data/content gamification based on the challenges of Balinese local wisdom was categorized as good according to expert assessments during the initial trial, with a score of 88.33%. This categorization was based on the average percentage of user interface design quality interpreted using a five's scale. The expert assessment ranged between 80 and 89%, indicating a good category. Based on this good categorization, in general there is no need to revise the user interface design any further. The user interface design quality of the ethnomathematics data/content gamification based on the challenges of Balinese local wisdom was categorized as good according to evaluators during the initial trial, with a score of 87.37%. The user interface design quality, according to evaluators, was categorized as good according to the five's scale. Therefore, there is no need to make any further improvements to the user interface design. The user interface design quality of the ethnomathematics

data/content gamification based on the challenges of Balinese local wisdom was categorized as good according to teachers during the initial trial, with a score of 85.87%. The percentage of user interface design quality according to the teachers' assessment is in the range of 80-89% which is proven to indicate a good category if referring to the quality standard of five's scale. Therefore, there is no need to make any further improvements to the user interface design.

There are 15 questions utilized to test the user interface design for the gamification of ethnomathematics data/content based on local Balinese wisdom challenges. The fifteen instruments were confirmed to have met the content validity test from four experts, including two education experts and two informatics experts. Item-1 pertains to the appropriateness of the user interface design for the main dashboard. Item-2 addresses the completeness of the features available on the main dashboard. Item-3 concerns the appropriateness of the user interface design for the login form. Item-4 focuses on the completeness of the features available on the login form. Item-5 relates to the appropriateness of the user interface design for the quiz form. Item-6 examines the completeness of the features available on the quiz form. Item-7 assesses the clarity of the gamification process within the quiz form. Item-8 evaluates the clarity of the gamification process of the ethnomathematics data/content based on local Balinese wisdom within the quiz form. Item-9 addresses the appropriateness of the user interface design for the learning topic. Item-10 pertains to the completeness of the features available on the learning topic form. Item-11 focuses on the clarity of the business process within the learning topic form. Item-12 assesses the clarity of the gamification material for the ethnomathematics data/content based on local Balinese wisdom included in the learning topic form. Item-13 concerns the appropriateness of the user interface design for badges. Item-14 addresses the completeness of the features available on the badge form. Item-15 evaluates the clarity of the business process within the badge form.

The results of this research have successfully addressed the limitations identified in previous studies. The limitations of Erita's research [10], which pertained to the absence of a user interface design that encapsulates the features of the e-module, have been resolved. This study effectively demonstrates a user interface design for the application features that can present material with content and stages of learning. The material provided is tailored to enhance students' abilities to solve complex problems relevant to everyday life situations. The difference between Erita's research and this study lies in the object of their study. Erita's research focused on e-modules, while this study focuses on the gamification of ethnomathematics content.

Moreover, the limitations highlighted in the research by Handikaningtyas et al. [11], regarding the insufficient in-depth and comprehensive presentation of gamification stages to ensure that students acquire knowledge and experience in addressing complex cultural issues and local wisdom, have also been addressed. This study presents an in-depth exploration of gamification through ethnomathematics data/content based on the challenges of local Balinese wisdom, thereby equipping students with knowledge pertinent to resolving complex cultural and local wisdom issues. The comparison between Handikaningtyas et al.'s research and this study lies in the form of the research object. Handikaningtyas et al.'s research focused on discussing the effectiveness of the gamification approach in supporting meaningful learning experiences. However, this study focuses on the use of gamification of ethnomathematics data/content based on the challenges of Balinese local wisdom, thus providing students with knowledge about solving complex cultural and local wisdom problems.

The limitations identified in the studies conducted by Gunawan et al. [12], Tampubolon et al. [13], Zhang et al. [14], Laksana et al. [15], Kadarisma et al. [16], and Choirudin et al. [17] have also been effectively resolved through the findings of this research. This study presents a gamified user interface design for ethnomathematics data/content grounded in the challenges of local Balinese wisdom, thereby showcasing features that accommodate material to strengthen students' capabilities in addressing complex problems encountered in daily life concerning culture and local wisdom.

This research fundamentally shares similarities and is supported by several previous studies. The research conducted by Biase et al. [41], Palmquist [42], Faudzi et al. [43], Pamudyaningrum et al. [44], Costa et al. [45], Doty et al. [46], and Zahra and Suryatiningsih [47] exhibits characteristics akin to this study, as all underscore the significance of employing user interface design as a preliminary step in understanding the physical form of gamification applications. Furthermore, the studies by Shenoy and Kumar [48], Namaziandost et al. [49], Ferdiansyah et al. [50], Roman et al.

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[51], and Hong et al. [52] share a similar principle with this research concerning the utilization of gamification in educational contexts.

The most significant finding is the novelty of this research is the existence of a user interface design for gamification of mathematics learning based on the challenges of Balinese local wisdom reality that can be used by students to solve ethnomathematics problems based on the challenges of Balinese local wisdom. This user interface design differs significantly from existing designs in similar ethnomathematics or gamification contexts. This user interface design emphasizes the ethnomathematics context, which can be used to solve complex everyday life problems that intersect with Balinese local wisdom. This gamification of mathematics learning highlights the gaming content aspects that internalize the challenges of the local wisdom of Bali, thereby enhancing students' critical thinking abilities in solving complex problems encountered in daily life that intersect with Balinese local wisdom. Furthermore, it aims to increase students' interest and motivation while preserving Balinese cultural heritage. In addition to this innovation, the research also presents certain limitations. Specifically, the limitations of this study include the absence of a physical manifestation of the gamification application for the ethnomathematics data/content based on the challenges of Balinese local wisdom, which is currently confined to the design of the user interface only. Furthermore, the results of this study only demonstrate its strengths in addressing the limitations of previous studies, which were limited to providing user interface design. However, they fail to address other limitations (such as technical issues) that may have remained unaddressed in previous studies.

4. Conclusions

In general, this research has successfully produced a user interface design for gamified ethnomathematics data/content based on the challenges of local Balinese wisdom, characterized by a design quality that falls within the 'good' category. The novelty of this study is evidenced by the incorporation of game content into Mathematics education through the internalization of challenges derived from local Balinese wisdom. Future work required to address the constraints identified in this research includes the development of a physical form of the gamified ethnomathematics application based on the challenges of local Balinese wisdom. Furthermore, it is necessary to address the technical limitations of previous studies, which were not fully addressed in this study. Another additional point to consider in the future is the use of other analysis methods or additional benchmarks in the analysis. The impact of the results of this research for application developers is that it makes it easier for developers to create physical forms of gamification applications that are tailored to data needs related to ethnomathematics. This ease of development is attributed to a user interface design that can serve as a foundational reference. The impact of the results of this study for teachers is to provide new knowledge to teachers about the facilities that they can later use to transfer knowledge to students by presenting fun, gamification-based learning.The impact of this research on students is that they will become familiar with a fun, gamification-based learning approach.

5. Declarations

5.1. Author Contributions

Conceptualization: I.K.L., D.G.H.D., and I.G.W.S.; Methodology: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Software: I.G.W.S., and D.G.H.D.; Validation: D.G.H.D., I.G.W.S. and I.W.S.W.; Formal Analysis: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Investigation: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Resources: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Data Curation: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Writing Original Draft Preparation: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Writing Review and Editing: I.K.L., D.G.H.D., I.G.W.S. and I.W.S.W.; Visualization: I.K.L., D.G.H.D., and I.G.W.S.; All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

5.3. Funding

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5.4. Institutional Review Board Statement

Not applicable.

5.5. Informed Consent Statement

Not applicable.

5.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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