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## Enhancing English Vocabulary Learning with Fisher-Yates Shuffle Algorithm

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### Abstract

The limited penetration of educational games compared to other genres highlights the need for more engaging digital learning tools, particularly for English as a Foreign Language (EFL) learning at the elementary level. This study developed an Android-based educational game that applies the Fisher-Yates Shuffle algorithm to support vocabulary and phrase mastery among Grade III students. The algorithm was employed to generate fair, unpredictable, and varied challenges by randomizing letters and words while integrating distractor elements to increase cognitive demand. The development process followed the Game Development Life Cycle (GDLC) framework, and the game was tested with 47 students at SDN 2 Pamulihan, Indonesia. Evaluation included a User Acceptance Test (UAT) and pre-post comprehension tests. Results showed high feasibility, with an overall acceptance rate of 86.06%. Moreover, significant learning gains were observed: vocabulary scores improved by 33%, phrase construction by 51.5%, and overall comprehension by 40.8%. These findings demonstrate that algorithmic randomization combined with gamification and contextualized materials enhances motivation and language acquisition. The study contributes by linking algorithm-driven fairness to measurable educational outcomes, offering evidence that adaptive educational games can complement classroom instruction in EFL learning.

**Keywords:** Educational game, Fisher-Yates Shuffle, English vocabulary, gamification, EFL learning.

## 1 INTRODUCTION

Educational games remain underrepresented in comparison to other mobile game genres on app distribution platforms. For instance, according to (Nauval et al., 2022a), educational games on Google Play total only 28,693 titles, while arcade, puzzle, and casual genres each surpass 50,000 titles. This disparity suggests that the educational game genre has not been fully leveraged, despite its potential to transform learning experiences, particularly in domains such as English vocabulary and phrase mastery for elementary school students.

Although vocabulary (and phrase) acquisition is central to language learning as it supports reading, listening, speaking, and writing (Baiq Siti Humaeratul Azizah et al., 2024) many classrooms still rely on conventional learning media, such as textbooks and workbooks, which offer limited interactivity and repetitive exercises (Anisa & Mega Febriani S, 2022). Existing digital tools or language-learning apps frequently reuse fixed question banks or rely on rote drills, leading to predictable patterns that can reduce student engagement and hinder long-term retention. In many such tools, the sequencing or ordering of vocabulary items is static or pseudo-random, which may allow learners to anticipate patterns and memorize positions rather than truly internalizing the language content.

At SD Negeri 2 Pamulihan, Cipicung District, Kuningan Regency, English is taught from grades I to VI, covering basic vocabulary, phrase construction, and simple sentence structures. However, based on observations and interviews with the English teacher (Ono Sudarsono, M.Pd.), Grade III students still struggle with converting scrambled letters into words and arranged words into meaningful phrases. These difficulties indicate that the existing media (textbook, handouts) fail to provide sufficient variation, repetition, and adaptive challenge to sustain learning.

Given these limitations, an interactive and engaging medium is needed one that prevents repetition, maintains fairness, and adapts challenge to the learner. In this work, we propose an Android-based educational game to assist students in arranging vocabulary and phrases in a fun, gamified environment. To generate non-repetitive, fair, and unpredictable challenge sequences, the game leverages the Fisher-Yates Shuffle algorithm, a widely used method for unbiased shuffling with time efficiency. By randomizing the positions of letters and words each time, the game reduces (Mery, 2024; Saokani et al., 2023) the chance that students memorize fixed patterns and encourage genuine problem solving.

Prior research has applied Fisher-Yates Shuffle in educational games in diverse contexts. For instance, (Krisdiawan & Ramdhany, 2018) used this algorithm in a mobile game for animal recognition in elementary contexts. (Pratama et al., 2024) applied it in their Things Bedroom game, reporting that 94% of users passed UAT testing. These precedents validate the technical feasibility of algorithmic shuffling in educational media, but they often stop short of rigorous pedagogical evaluation (e.g. using pre–post tests or field trials with EFL learners).

Meanwhile, many language learning apps or digital tools do not incorporate truly randomized ordering of stimuli or adaptive mechanisms. This limitation reduces their ability to maintain engagement or to prevent learners from overfitting to patterns. Thus, a gap remains: very few studies combine algorithmic randomness (via Fisher-Yates Shuffle) with empirical evaluation (pre–post tests, UAT) in the context of English vocabulary and phrase learning for elementary students.

To bridge that gap, this study is guided by the following objectives and research questions / hypotheses:

1. Objectives:
  - a. Develop an Android-based educational game that supports students in interactively arranging English vocabulary and phrases.
  - b. Enhance learner engagement and comprehension through an immersive, playful experience.
  - c. Apply Fisher-Yates Shuffle to randomize letters and words, producing varied and unpredictable challenges that promote deeper understanding.
2. Research Questions / Hypotheses:

RQ1: Does using an educational game with Fisher-Yates-based randomization lead to a statistically significant improvement in students' vocabulary and phrase comprehension (pre-test vs post-test)?

RQ2: Is the Android game media rated as acceptable and usable (via UAT) by the students, in terms of interface, usability, content, and learning experience?

H1: Students who use the Fisher-Yates Shuffle-powered game will show greater gain scores in vocabulary and phrase tests than what is predicted by traditional methods.

H2: The game will achieve an acceptability rating of  $\geq 80\%$  in UAT (considered very feasible for classroom use).

This study is expected to make both a technical contribution (demonstrating how Fisher-Yates Shuffle can be integrated with distractor logic in language games) and a pedagogical advance (evidence of learning gain in real classroom context). Practically, the game can serve as a motivating tool for students and as a dynamic evaluative alternative for teachers, aligning with curriculum needs in SD-level English education.

## 2 LITERATURE REVIEW

To situate this research within existing scholarship, several studies on educational games and the implementation of the Fisher-Yates Shuffle algorithm are compared. The following table presents a summary of prior works, their methods, findings, and limitations.

Table 1. Comparison of Previous Studies on Educational Games Using Fisher-Yates Shuffle

<i>Author &amp; Year</i>	<i>Context &amp; Method</i>	<i>Findings</i>	<i>Limitations</i>	<i>Gap Addressed by This Study</i>
<b>Ramadhan (2022)</b> (Ramadhan, 2022)	Developed hijaiyah letter game with Fisher-Yates Shuffle; evaluated usability.	Increased game variation and user motivation.	Focused only on religious content; no empirical test of learning outcomes.	Extends algorithm application to English learning and measures pre-post learning gains.
<b>Nauval et al. (2022)</b> (Nauval et al., 2022b)	Android-based game for cultural learning; Unity engine.	Increased motivation and engagement.	Randomization relied on pseudo-random logic; evaluation limited to engagement.	Uses Fisher-Yates Shuffle for unbiased randomization and evaluates comprehension gains.
<b>Mery (2024)</b> (Mery, 2024)	Web-based educational game using Fisher-Yates Shuffle.	Demonstrated fairness and efficiency of algorithm.	Focused only on technical performance; no pedagogical evaluation.	Links algorithmic fairness to cognitive engagement in language learning.
<b>Saokani et al. (2023)</b> (Saokani et al., 2023)	Compared Fisher-Yates vs Linear Congruent in Nahwu learning media.	Fisher-Yates produced fairer randomization.	Evaluation was purely algorithmic; no user learning measurement.	Combines algorithm validation with empirical classroom testing.
<b>Azizah et al. (2024)</b> (Baiq Siti Humaeratul Azizah et al., 2024)	Meta-analysis of gamified tools (Wordwall, scramble, crossword).	Gamification improves vocabulary acquisition.	Tools relied on static content; lacked dynamic randomization.	Introduces algorithm-driven variety to sustain engagement.
<b>Pratama, Krisdiawan, &amp; Yulyanto (2024)</b> (Pratama et al., 2024)	Developed "Things Bedroom" game with Fisher-Yates Shuffle; UAT tested.	Achieved 94% user acceptance.	Did not measure learning improvement, only usability.	Evaluates both usability and learning outcomes simultaneously.
<b>Krisdiawan &amp; Ramdhany (2018)</b> (Krisdiawan & Ramdhany, 2018)	Animal recognition game with Fisher-Yates Shuffle.	Demonstrated algorithm's applicability to educational games.	Evaluation descriptive; no rigorous testing.	Advances to structured GDLC methodology with pre-post empirical validation.

From table 1, several critical points emerge:

1. **Scope Limitation** Most prior works applied Fisher-Yates Shuffle to **narrow domains** (e.g., hijaiyah letters, cultural learning, object recognition), whereas English vocabulary and phrase learning essential for early foreign language acquisition remains underexplored.
2. **Evaluation Limitation** Many studies emphasized **usability** e.g., UAT ratings in (Pratama et al., 2024) or **technical fairness** (Mery, 2024; Saokani et al., 2023), but rarely measured **learning gains** through pre–post testing, leaving uncertain the real educational effectiveness.
3. **Algorithmic Novelty** While Fisher-Yates Shuffle has been shown to produce unbiased randomization, previous works did not explicitly link this property to **pedagogical impact**, such as preventing rote memorization and sustaining cognitive engagement.
4. **Methodological Rigor** Prior studies often lacked structured development frameworks, focusing on ad hoc implementations. Few works adopted comprehensive methodologies such as the **Game Development Life Cycle (GDLC)**, which ensures systematic design, testing, and release.

Given these limitations, the present study contributes by:

1. Targeting **English vocabulary and phrase mastery** at the elementary level, a domain critical for foundational language acquisition.
2. Combining **algorithmic fairness (Fisher-Yates Shuffle)** with **structured design (GDLC)**.
3. Conducting both **UAT** and **pre–post testing**, ensuring evaluation covers usability and measurable learning gains.
4. Providing empirical evidence that algorithmic randomization not only improves fairness but also enhances learner engagement and comprehension.

Thus, this research fills an important gap by integrating **technical innovation** with **pedagogical validation**, offering a model for future educational game development that balances usability, fairness, and learning effectiveness.

### 3 RESEARCH METHODS

#### 3.1 Data Collection Method

The study employed four data collection techniques to ensure triangulation and reliability of findings:

1. **Literature Study** – A comprehensive review of books, journals, and articles related to the Fisher-Yates Shuffle algorithm, Android-based educational games, and vocabulary/phrase learning strategies was conducted to establish a theoretical foundation.
2. **Observation** – Classroom observations at *SDN 2 Pamulihan* documented the teaching practices and learning difficulties faced by Grade III students in vocabulary and phrase construction.
3. **Interview** – Semi-structured interviews with the English teacher (*Ono Sudarsono, M.Pd.*) were conducted to gain insights into existing instructional methods, challenges, and expectations for supplementary media.
4. **Questionnaires and Tests** – The research applied **pre-tests and post-tests** to measure vocabulary and phrase comprehension before and after game use. Additionally, a **User Acceptance Test (UAT)** questionnaire evaluated usability, interface, and learning experience. The participants were 47 Grade III students.

#### 3.2 Instrument Validity and Reliability

1. **Content validity** was established by involving two language experts and one instructional technology expert to review the test items and questionnaires.
2. **Reliability** was verified using Cronbach's Alpha on the UAT questionnaire ( $\alpha \geq 0.80$ , indicating high reliability).

3. The pre-test and post-test items were piloted in a parallel class, achieving item difficulty within acceptable ranges (0.30–0.70) and discrimination indices above 0.25.

### 3.3 System Development Methods

The development model used is the **Game Development Life Cycle (GDLC)**, which includes initiation, pre-production, production, alpha testing, beta testing, and final release (Krisdiawan, 2018; Krisdiawan & Darsanto, 2019).

GDLC was selected because it provides a structured, iterative framework tailored for game projects, unlike traditional software models (e.g., Waterfall). GDLC emphasizes prototyping, user testing, and refinement, which are critical in educational games where usability, engagement, and learning impact must be continuously validated. This method ensures that feedback from students (the end-users) directly informs design refinements.

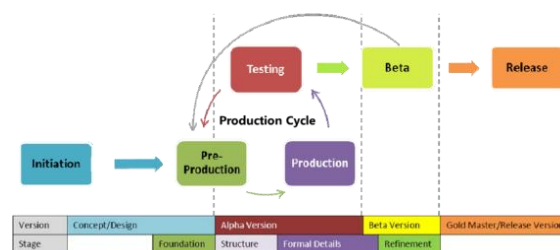


Figure 1. GDLC Stages

The main stages include:

1. **Initiation** – Problem identification (low vocabulary/phrase mastery) and needs analysis.
2. **Pre-Production** – Game design planning (mechanics, characters, levels, challenges).
3. **Production** – Development of features such as randomized word/letter challenges, scoring, and feedback system.
4. **Alpha Testing** – Internal testing of algorithms and interface.
5. **Beta Testing** – External testing with target users for usability and feedback
6. **Final Release** – Deployment of the improved version for classroom use.

### 3.4 Problem Solving Methods

The **Fisher-Yates Shuffle algorithm** was implemented to randomize letters and words in vocabulary and phrase tasks. To increase cognitive challenge, **distractor elements** were deliberately inserted:

1. For **vocabulary tasks**: additional vowels and consonants were added to prevent students from merely relying on memorization. Random letters from vowel categories (a, e, i, o, u) and consonants (other than vowels) are added as distractions in the vocabulary rearrangement process.
2. For **phrase tasks**: extra words were inserted to make phrase construction more cognitively demanding. Several additional words taken from the question input data were included to increase the complexity of the phrase arrangement.

This design ensures that each challenge requires deeper processing and discourages simple pattern recognition. Once the shuffle elements are combined with the main vocabulary or phrase into a single array, the Fisher-Yates Shuffle algorithm is applied to generate a random sequence used in the gameplay. Here is a flowchart of the Fisher-Yates Shuffle algorithm:

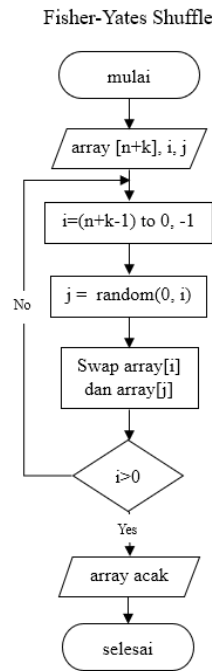


Figure 2. Flowchart Algorithm Fisher-Yates Shuffle  
 Source: Andriyat Rio & Sugiharto Tito, 2025

Based on Figure 2, the Fisher Yates algorithm flowchart above, the pseudocode and natural language can be explained as follows:

Table 2. Natural Language and Pseudocode Fisher-Yates Shuffle

Natural Language of the Fisher-Yates Shuffle	Pseudocode of the Fisher-Yates Shuffle
<ol style="list-style-type: none"> <li>1. Start</li> <li>2. Get the main vocabulary/phrase (n)</li> <li>3. Get the letter/word suffix from the question input (k)</li> <li>4. Combine into Array[n + k]</li> <li>5. Initialize: Provide an array [n + k] and variables i and j.</li> <li>6. Loop from i = (n + k - 1) to 0: Start from the last element and work backward to the first element.</li> <li>7. Randomly select j between 0 and i.</li> <li>8. Swap: Swap elements in array[i] with array[j].</li> <li>9. Condition i &gt; 0: If i &gt; 0, return to the process of selecting j and swapping elements. If i = 0, the loop stops and the array is completely randomized.</li> <li>10. Display the random array.</li> <li>11. Done.</li> </ol>	<pre> function fisherYatesShuffle(array A):     n ← length(A)     for i from n-1 downto 1:         j ← random integer between 0 and i         swap A[i] with A[j]     return A         </pre>

Table 3. Vocabulary Letter Randomization Results

Range(i)	Roll(j)	Scratch	Result
		S, M, A, L, L, E, R	
1-7	3 (A)	S, M, L, L, E, R	<b>A</b>
1-6	6 (E)	S, M, R, L, L,	<b>E, A</b>
1-5	4 (L)	S, M, R, L	<b>L, E, A</b>
1-4	1 (S)	M, R, L	<b>S, L, E, A</b>
1-3	2 (M)	L, R	<b>M, S, L, E, A</b>
1-2	2 (R)	L	<b>R, M, S, L, E, A</b>
<b>Randomization Results</b>			<b>L R M S L E A</b>

Table 4. Results of Randomization of Phrases

Range(i)	Roll(j)	Scratch	Result
		The, classroom, is, dirty, and, narrow, beautiful, quickly	
1-8	3 (is)	The, classroom, dirty, and, narrow, beautiful, quickly	<b>is</b>
1-7	6 (narrow)	The, classroom, quickly, dirty, and, beautiful	<b>narrow, is</b>
1-6	2 (classroom)	The, quickly, dirty, and, beautiful	<b>classroom, narrow, is</b>
1-5	4 (dirty)	The, beautiful, quickly, and	<b>dirty, classroom, narrow, is</b>
1-4	1 (The)	beautiful, quickly, and	<b>The, dirty, classroom, narrow, is</b>
1-3	2 (beautiful)	and, quickly	<b>beautiful, The, dirty, classroom, narrow, is</b>
1-2	2 (quickly)	and	<b>quickly, beautiful, The, dirty, classroom, narrow, is</b>
<b>Randomization Results</b>			<b>and, quickly, beautiful, The, dirty, classroom, narrow, is</b>

Table 2 (Vocabulary Letter Randomization Results) and Table 3 (Phrase Word Randomization Results) present the results of the implementation of the Fisher-Yates Shuffle algorithm in the letter and word randomization process. In Table 1, the process of randomizing letters from vocabulary that has been added with two letters of trickery, such as in the word small with the letters e and r added. All letters, including trickery, are then randomized without repetition of positions to form varied answer choices. Table 3 shows the results of word randomization from simple phrases or sentences that have also been added to two tricky words, namely beautiful and quickly, then randomized using the same algorithm. The results in both tables showed that the Fisher-Yates algorithm was able to generate a fair and unpredictable random distribution, thus enriching the variety of answer choices in each game session and increasing cognitive challenges for students.

The algorithm guarantees unbiased shuffling, ensuring that every permutation has an equal probability of occurrence (Mery, 2024). Combined with distractors, this creates varied and unpredictable challenges, fostering higher-order cognitive engagement such as analysis and problem-solving.

## 4 RESULTS AND DISCUSSION

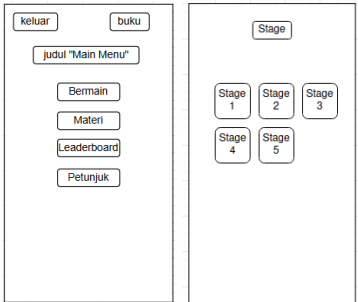
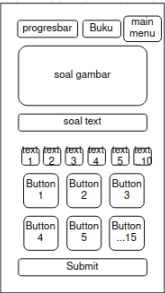
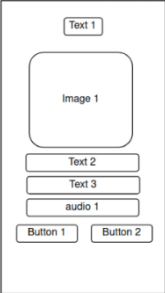
### 4.1 Proposed System Analysis

The proposed system analysis includes Game Design Document (GDD) of the educational game to be developed, as follows:

**Game Design Document (GDD)**

**a. Storyboard**

Table 5. Storyboard

Information	Scene
<p>After login, you will be redirected to the Main Menu with:</p> <ol style="list-style-type: none"> <li>1. Exit (quit game)</li> <li>2. Play (start game)</li> <li>3. Materials (study &amp; get books)</li> <li>4. Leaderboard (view scores)</li> <li>5. Instructions (how to play)</li> <li>6. Books (life)</li> <li>7. Title</li> </ol> <p>Choosing Easy/Medium/Hard directs you to the Stage Page, with 5 stages per level.</p>	
<p>After selecting a stage, you enter the <b>Gameplay page</b> with an interactive interface to compose vocabulary/phrases. It includes a progress bar, book-shaped lives, and navigation to the main menu. Questions appear as images and text, while answers use input fields with randomized options (Fisher-Yates Shuffle). The result is locked by pressing <b>Submit</b>.</p>	
<p>The Material Page displays vocabulary/phrases with text, image, spelling, translation, and (for vocabulary) pronunciation audio. Navigation uses back/next buttons, and as gamification, users earn 1 life per minute of reading or after a listening session.</p>	

**b. Game Layout Chart**

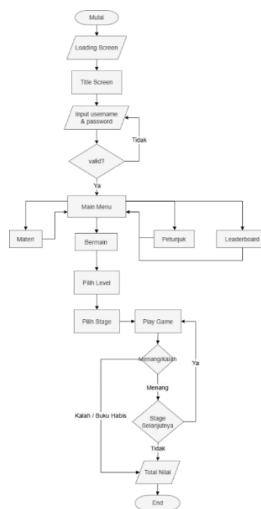


Figure 3. Game Layout Chart

This game layout chart describes the structure of a system-based educational game flow, starting from authentication to the completion stage. Players follow a series of interactive processes, including level selection and decision-making in game sessions, designed to support learning effectiveness as well as ease of navigation.

**4.2 System Design**

The system design is carried out to implement solutions to problems that have been analyzed previously. This design process uses the Unified Modeling Language (UML) approach as a system modeling method to visually and systematically describe the structure and flow of the system.

**1. Use Case Diagram and Activity Diagram**

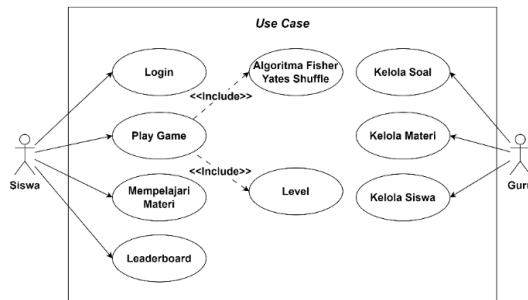


Figure 4. Use case diagram

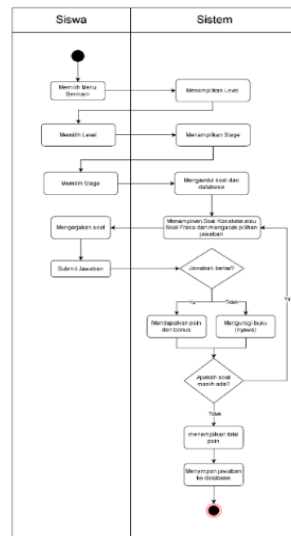


Figure 5. Activity diagram

The Use Case Diagram (Figure 4) illustrates the core interactions between students, teachers, and the system, encompassing login, gameplay, access to learning materials, and student data management. In parallel, the Activity Diagram of Play Game (Figure 5) represents the procedural flow of student activities, beginning with level and stage selection and culminating in the system’s recording of game outcomes.

2. Class Diagram and Sequence Diagram Play Game

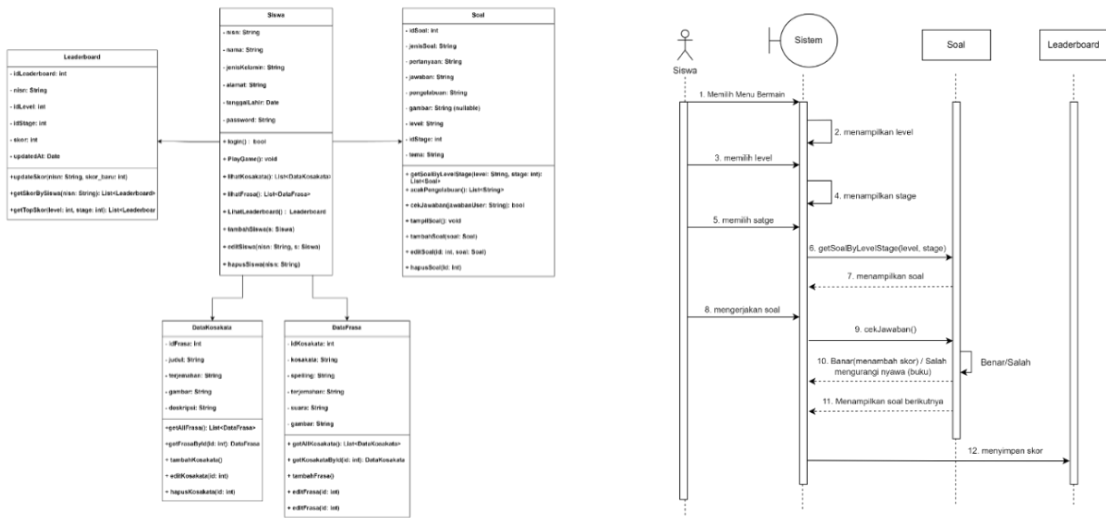
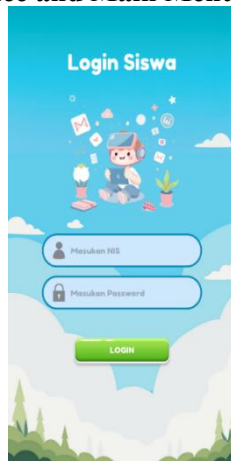


Figure 6. (a) Class Diagram; (b) Sequence Diagram Play Game

The Class Diagram (a) illustrates the structural design of the system by depicting the relationships among classes that collectively support the functionality of the educational game. In contrast, the Gameplay Sequence Diagram (b) demonstrates the dynamic interactions between student actors and system components throughout the gameplay process.

3. Interface Game

a. Login Interface and Main Menu



(a) Interface Login



(b) Interface Main Menu

Figure 7. (a) Interface Login; (b) Interface Main Menu

Figure 7(a) presents the login interface, functioning as the application’s home page where users enter their NISN and password for authentication, ensuring access only for registered users. Figure 7(b) displays the main menu interface shown after successful login, serving as the central navigation hub with features including exit, total scores, books, play, leaderboard, materials, and information.

### b. Level and Stage Interface



(a) Interface Level



(b) Interface Stages

Figure 8. (a) Interface Level; (b) Interface Stages

Figure 8(a) illustrates the level selection interface accessed from the play menu, where users choose among three difficulty levels—Easy, Medium, and Hard—based on their ability or learning progress. Subsequently, Figure 8(b) presents the stage selection interface, comprising five sequential stages beginning from Stage 1.

### c. Gameplay Interface, Game Win, and Game Over



(a) Interface Gameplay



(b) Interface Game Win

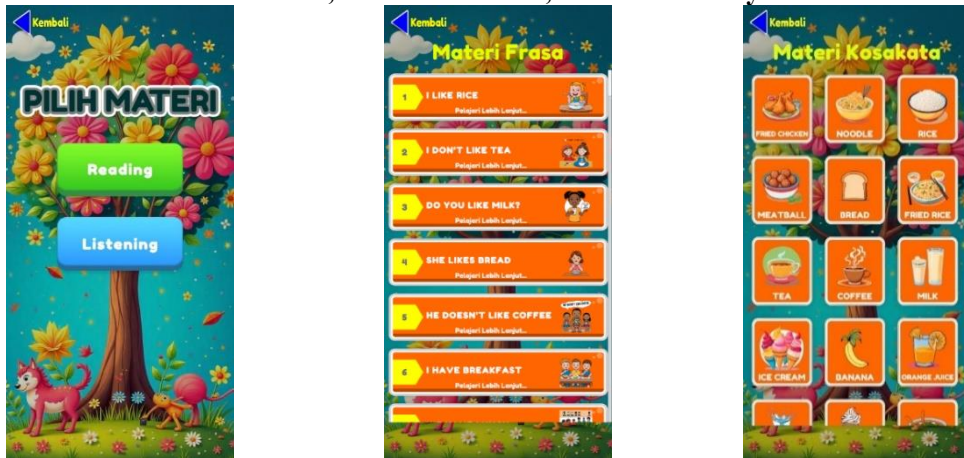


(c) Interface Game Over

Figure 9. (a) Interface Gameplay; (b) Interface Game Win; (c) Interface Game Over

Figure (a) illustrates the gameplay interface, which serves as the main workspace containing questions (text or images), life indicators, time, scores, and interactive components such as answer options and a submit button. Figure (b) presents the Game Win interface, displayed after completing all problems in a stage, showing the score with options to continue or return to the main menu. Conversely, Figure (c) depicts the Game Over interface, appearing when lives are exhausted or the stage is not completed, providing final score information and navigation choices.

d. Material Menu Interface, Phrase Material, and Vocabulary Material



(a) Material Menu Interface (b) Phrase Material Interface (c) Vocabulary Material Interface  
 Figure 10. (a) Material Menu Interface; (b) Phrase Material Interface; (c) Vocabulary Material Interface

Figure 10(a) presents the material menu interface, offering access to two learning modes: Reading (phrases) and Listening (vocabulary). Figures 10(b) and 10(c) display the respective material lists, containing collections of phrases or vocabulary accompanied by illustrations to support contextual understanding.

e. Detailed Interface of Reading, Listening, and Leaderboard Materials



(a) Detail Reading Interface (b) Detail Listening Interface (c) Leaderboard Interface  
 Figure 11. (a) Detail Reading Interface; (b) Detail Listening Interface; (c) Leaderboard Interface

Figure 11(a) illustrates the Reading material interface, consisting of phrase text, supporting images, and book rewards upon completion. Figure 11(b) depicts the Listening material interface, presenting vocabulary with audio, illustrations, and a book reward after the session. Figure 11(c) shows the leaderboard interface, a ranking table based on total scores designed to motivate users through competitive achievement monitoring.

4.3 User Acceptance Test

The User Acceptance Test (UAT) involved 47 Grade III students and evaluated four dimensions: Display, Learning Process, Material, and Comprehension Improvement, using 14

questionnaire items. The overall feasibility rate reached 86.06%, which falls into the “very feasible” category for classroom adoption.

Table 6. Respondents' Statements and Answers (Students)

No	Statement	Answer			
		Strongly agree	Agree	DisAgree	Strongly Disagree
<b>A. Display</b>					
1	The app's interface is attractive and fun to use.	29	15	1	2
2	In-app navigation is easy to understand and use.	27	19	1	
3	The writing and images in this game are easy to read and understand.	26	20	1	
<b>B. Learning Process</b>					
4	This game helps me in understanding English vocabulary.	27	18	2	
5	This game helps me in understanding English phrases.	23	20	3	1
6	This game can be used for learning, not just for playing.	23	20	2	2
7	The questions in this game are according to my difficulty level.	23	21	3	
8	The time given when working on the question is according to the level of difficulty of the question	22	24	1	
<b>C. Material</b>					
9	The reading material (Phrases) in this game is easy to understand.	22	20	3	2
10	The listening material (Vocabulary) in this game is easy to understand.	26	18	3	
11	The sound of in-game material is audible.	23	20	3	1
<b>D. Increased Understanding</b>					
12	This game increased my motivation to learn more English vocabulary and phrases.	22	22	2	1
13	This game improved my understanding of English vocabulary and phrases.	25	19	2	1
14	I became more able to compose words and sentences after playing this game.	22	23	2	

Table 7. Summary of Results UAT

<i>Dimension</i>	<i>Avg. Score (%)</i>	<i>Key Insights</i>
<i>Display</i>	88.3	Attractive, child-friendly, easy navigation; reduced extraneous cognitive load.
<i>Learning Process</i>	85.7	Level calibration matched skills; aligned with flow theory for engagement.
<i>Material</i>	84.9	Contextual and curriculum-aligned; clear sound and visuals.
<i>Comprehension Improvement</i>	85.5	Boosted motivation and ability to compose words/phrases.

Based on the data obtained from UAT, the following results were obtained:

- a. **Display (88.3%)** Students strongly agreed that the interface was attractive, fun, and easy to navigate. This suggests that the game's **child-friendly design** reduced extraneous cognitive load and supported intuitive interaction. High ratings in this aspect are consistent with (Pratama et al., 2024), who also found that appealing visual design contributed to a 94% acceptance rate in their "Things Bedroom" game. However, unlike that study, the present work extends beyond usability by linking interface satisfaction to learning outcomes through pre–posttests.
- b. **Learning Process (85.74%)** Students agreed that the game facilitated understanding vocabulary and phrases, provided challenges aligned with their abilities, and offered time allocation consistent with difficulty levels. This indicates that the **difficulty calibration and level system** successfully maintained engagement, aligning with flow theory which posits that learners are most engaged when challenges match their skill level. This finding reinforces (Baiq Siti Humaeratul Azizah et al., 2024), who reported that gamification elements (scramble, crossword, Wordwall) enhanced vocabulary mastery, although those tools relied on static content rather than algorithmic variety.
- c. **Material (84.9%)** Respondents found the reading and listening materials accessible and clear, with audible sound quality. The use of **contextual vocabulary and simple phrases** aligned with the curriculum likely supported comprehension. While earlier studies (Mery, 2024; Ramadhan, 2022) demonstrated the technical feasibility of Fisher-Yates Shuffle in educational games, they did not explicitly examine material relevance. Our findings suggest that **curriculum alignment combined with randomization** increases both usability and perceived usefulness.
- d. **Comprehension Improvement (85.5%)** Students reported that the game improved their motivation and ability to compose words and sentences. This subjective perception aligns with objective evidence from the comprehension test (see §4.5), where mean scores increased significantly. Motivation is a key mediator in learning effectiveness: games that students find enjoyable encourage repeated practice, which in turn strengthens vocabulary acquisition.

High acceptance is explained by (a) fair/randomized challenges via Fisher-Yates Shuffle, (b) gamification (lives, scores, leaderboards), (c) contextual materials, and (d) balanced difficulty. Similar to (Pratama et al., 2024), high usability was confirmed, but unlike previous works, this study connects UAT with measurable learning outcomes.

**Limitations of UAT results.** Although high scores (>84%) across all aspects demonstrate feasibility, UAT data represent **subjective perceptions** and may be influenced by novelty effects (students' excitement about trying a new game). In addition, the study was conducted in a **single school with 47 respondents**, which limits generalizability. Further replication across diverse contexts and longer exposure would strengthen external validity.

#### 4.4 Comprehension Test Response

The **pre–post test** revealed significant improvements:

Table 8. Comprehension Test Response

<i>Aspect</i>	<i>Pre-Test (Mean)</i>	<i>Post-Test (Mean)</i>	<i>Gain</i>	<i>% Increase</i>
<i>Vocabulary</i>	28.94	38.50	+9.56	+33%
<i>Phrase Construction</i>	21.06	31.90	+10.84	+51.5%
<i>Total Score</i>	50.00	70.40	+20.40	+40.8%

The improvement can be influenced by several factors including Fisher-Yates Shuffle ensures fair/random tasks, Distractors increase cognitive engagement, Gamification encourages repeated practice, Contextual content strengthens semantic associations.

**Comparison with prior studies:** Gains (+40.8%) exceed typical improvements (20–30%) in gamified vocabulary studies (Baiq Siti Humaeratul Azizah et al., 2024). Unlike (Pratama et al., 2024) who only measured usability, this study links usability with significant learning impact.

**Limitations:** One-group design (no control), limited sample, short-term gains only, and lack of reported effect size (t-test, Cohen's d).

**Implications:** The integration of **algorithmic randomization, gamification, and contextual content** significantly enhanced vocabulary and phrase mastery, offering an empirically validated model for technology-based language learning.

## 5 CONCLUSION

This study developed and evaluated an Android-based educational game designed to improve English vocabulary and phrase mastery among elementary school students, utilizing the Fisher-Yates Shuffle algorithm to generate fair and varied challenges. The integration of algorithmic randomization, distractor-based tasks, and gamification elements resulted in both high user acceptance and measurable learning improvements.

The User Acceptance Test (UAT) involving 47 Grade III students yielded an overall feasibility score of 86.06%, indicating that the game was perceived as highly engaging, usable, and relevant to learning needs. More importantly, comprehension test results demonstrated substantial learning gains: vocabulary scores increased by 33%, phrase construction improved by 51.5%, and overall comprehension rose by 40.8%. These findings suggest that the combination of algorithmic fairness, contextualized materials, and gamified reinforcement not only sustains student motivation but also enhances language acquisition more effectively than static, conventional methods.

Compared with prior studies that primarily focused on usability or technical implementation, this research provides empirical evidence linking algorithmic shuffling to improved learning outcomes in English as a Foreign Language (EFL) contexts. This strengthens the claim that algorithm-driven educational games can complement teacher-led instruction by offering personalized, varied, and cognitively stimulating learning opportunities.

Nevertheless, several limitations must be acknowledged. The study was conducted in a single school with a relatively small sample size, and the evaluation was limited to short-term outcomes. Longitudinal studies with larger and more diverse samples are needed to confirm the long-term effectiveness and generalizability of this approach. Additionally, future research should incorporate statistical effect size analysis and controlled experimental designs to strengthen causal inferences.

In conclusion, this study contributes to the growing body of evidence supporting the role of serious games in language education. By demonstrating how the Fisher-Yates Shuffle algorithm can create fairness and variety in vocabulary and phrase learning, it provides a novel direction for the design of adaptive and engaging digital learning tools.

## BIBLIOGRAPHY

- Andriyat Rio, & Sugiharto Tito. (2025). Comparison of Shuffle Algorithms For Randomness, Time Complexity and Space Complexity. *JOURNAL OF INFORMATICS AND TELECOMMUNICATION ENGINEERING*, 8(2), 279–291. <https://doi.org/10.31289/jite.v8i2.13179>
- Anisa, & Mega Febriani S. (2022). Pembelajaran Bahasa Inggris Menggunakan Metode English Is Fun di Sekolah Dasar. *Karimah Tauhid*, 1, 352–356.
- Baiq Siti Humaeratul Azizah, Hidayati, Irwandi, & Edi. (2024). Meta-Analysis: The Effect of Word Search, Wordwall, Crossword, & Scramble Games in Learning English Vocabulary.

- Journal of Language and Literature Studies*, 4(1), 71–83.  
<https://doi.org/10.36312/jolls.v4i1.1756>
- Krisdiawan, R. A. (2018). Implementasi Model Pengembangan Sistem GDLC dan Algoritma Linear Congruential Generator Pada Game Puzzle. *Nuansa Informatika*, 12(2), 1–9.  
<https://doi.org/https://doi.org/10.25134/nuansa.v12i2.1634>
- Krisdiawan, R. A., & Darsanto. (2019). PENERAPAN MODEL PENGEMBANGAN GAME GDLC (GAME DEVELOPMENT LIFE CYCLE )DALAM MEMBANGUN GAME PLATFORM BERBASIS MOBILE. *TEKNOKOM*. <https://doi.org/10.31943/teknokom.v2i1.33>
- Krisdiawan, R. A., & Ramdhany, T. (2018). Implementasi Algoritma Fisher Yates Pada Games Edukasi Pengenalan Hewan Untuk Anak SD Berbasis Mobile Android. *Jurnal Komputer Bisnis*, 11(2), 14–22. <http://jurnal.lpkia.ac.id/index.php/jkb/article/view/213>
- Mery, W. (2024). IMPLEMENTASI ALGORITMA FISHER-YATES SHUFFLE PADA GAME EDUKASI SEBAGAI PENDUKUNG PEMBELAJARAN BERBASIS WEB. *Jurnal Informatika Dan Teknik Elektro Terapan*, 12(2). <https://doi.org/10.23960/jitet.v12i2.4116>
- Nauval, M., Ruslianto, I., & Rahmayuda, S. (2022a). RANCANG BANGUN GAME EDUKASI BERBASIS ANDROID SEBAGAI MEDIA PEMBELAJARAN BUDAYA INDONESIA MENGGUNAKAN UNITY ENGINE. *Coding Jurnal Komputer Dan Aplikasi*, 9(03), 491. <https://doi.org/10.26418/coding.v9i03.49393>
- Nauval, M., Ruslianto, I., & Rahmayuda, S. (2022b). RANCANG BANGUN GAME EDUKASI BERBASIS ANDROID SEBAGAI MEDIA PEMBELAJARAN BUDAYA INDONESIA MENGGUNAKAN UNITY ENGINE. *Coding Jurnal Komputer Dan Aplikasi*, 9(03), 491. <https://doi.org/10.26418/coding.v9i03.49393>
- Pratama, A. S., Krisdiawan, R. A., & Yulyanto, Y. (2024). Implementasi Algoritma Fisher Yates Suffle Pada Game Things Bedroom. *Digital Transformation Technology*, 4(1), 196–205. <https://doi.org/10.47709/digitech.v4i1.3753>
- Ramadhan, A. (2022). Algoritma Fisher-Yates Shuffle Pada Game Edukasi Jumble Hijaiyah. *Jurnal Teknologi Informatika Dan Komputer*, 8(1), 94–106. <https://doi.org/10.37012/jtik.v8i1.759>
- Saokani, U., Irfan, M., Maylawati, D. S., Abidin, R. J., Taufik, I., & Hay's, R. N. (2023). Comparison of the Fisher-Yates Shuffle and the Linear Congruent Algorithm for Randomizing Questions in Nahwu Learning Multimedia. *Khazanah Journal of Religion and Technology*, 1(1), 10–14. <https://doi.org/10.15575/kjrt.v1i1.159>