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Fisher-Yates and fuzzy Sugeno in game for children with special needs

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ABSTRACT

As a country that has its language, English is an international language that needs to be mastered. Until now, the mastery of English in Indonesian on an international scale is in a low category. Learning English should be taught to children from an early age. For children with special needs, special learning methods are needed so that the material is conveyed. Educational games can be used as an interesting learning media. In this study, an English educational game was created that had the concepts of a quiz, rearrange, and matching. Fisher-Yates algorithm was applied to randomize the questions so that the questions that came out varied. Fuzzy Sugeno algorithm is also applied to the scoring calculation, with input variables of time, value, and the number of stars obtained. The system test outcomes show that the application of the Fisher-Yates algorithm was successful because every question that came out was randomized. The application of the Fuzzy Sugeno algorithm happened also successful because of the high degree of accuracy. Besides, the use of games shows there is an increase in student understanding as evidenced by the acquisition of grades. The results of the average value in doing the test is from 80.41 to 88.3 after playing the game.

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1. INTRODUCTION

English is an international language that needs to be mastered by the public. In Indonesia, mastery of English on an international scale is in a low category [1]. In accordance with the the concept of educational for All (EFA), education is something that can be obtained by everyone. EFA is the mandate of the 1945 Constitution, namely article 31 paragraph (1), which reads "Every citizen has the right to education" [2]. The word "every" indicates that every child in Indonesia has the right to receive a proper education, including Children with Special Needs. Children with autism and mental retardation have different ways of learning, but in general, these children have a way of learning or abilities that stand out in the visual field [3]. Therefore, interactive media need to be used to support the learning process to make it more interesting and easy to understand [4, 5]. Educational games can be used as one of these media [6-8].

The game made in this study will be used to support one of the material in English grade junior high school, namely the introduction of animals (pet and wild animals) by the 2013 Curriculum [9]. The game that we built has the concepts of a quiz, rearrange, and matching. In this game, the Fisher-Yates algorithm is applied for randomization of questions. The reason why choosing this algorithm is because Fisher-Yates is able to shuffle questions optimally [10-16]. If the games that are made are used in all schools at one time, then every student will not get the same question. This is important to train students' concentration and focus in learning.

Fisher-Yates shuffle (taken from the names Ronald Fisher and Frank Yates) or also known as Knuth shuffle (taken from the name Donald Knuth), is an algorithm to produce a random permutation of a finite set, in other words, to randomize a set [17-19]. If implemented correctly, the results of this algorithm will not be biased, so each permutation has the same possibility [20]. Fuzzy Sugeno algorithm applied in this game applied for scoring. Fuzzy Sugeno has also been applied to several games for several purposes, such as prediction of NPC Player [21, 22], Strategy [23], toddler nutrition [24], and clue [25].

This study aims to apply and analyze the performance of Fisher-Yates and Fuzzy Sugeno algorithms in the English game for children with special needs. In addition, the game that was built was also tested on students with special needs to measure the level of understanding of English material before and after playing the game.

2. RESEARCH METHOD

The development method used is the game development life cycle (GDLC). GDLC is the stage to build a game (digital game) that is done sequentially. There are six main phases in GDLC, including: 1) initialization, 2) pre-production, 3) production, 4) testing, 5) beta release, and 6) full version release [26]. The method used to observe student understanding in this study is a quasi-experimental method, which is a form of an experiment where the main characteristic of validation is not to do random assignments, but instead to use an existing group which in this case is an ordinary class. Quasi-experiments are almost the same as actual experiments, the difference lies in the use of subjects, namely quasi-experiments are not random assignments, but rather by using an existing group (intact group) [27].

The reason for not doing this random assignment is because the researcher can't change the existing class so the researcher can determine which research subjects belong to the experimental groups. The groups that are in one class are usually already balanced so that if the researcher creates a new class group it is feared that the natural atmosphere of a class will be lost. To avoid losing the natural atmosphere of the class, the researchers used a quasi-experimental method using classes that already existed in the population.

In the study there are two main variables, namely the independent variable or the predictor variable (independent variable) is often given an X notation is the cause variable or which is thought to provide an influence or effect on other events, and the dependent variable or the response variable (dependent variable) is often called the Y notation, i.e. the variable which is caused or the effect of the independent variable [27]. In this study, there are two variables, namely the independent variable and the dependent variable. The use of the Pet and Wild game is carried out in the experimental class. Learning by using the game pet and wild is placed as an independent variable, while student learning outcomes are placed as a dependent variable.

The research design used in this study is the one group pretest post-test design, which is a form of research design in a quasi-experimental method. The experimental group was selected without random assignments then held pretests before treatment and post-test after treatment [27]. The sample in this study were three children with special needs who were students at an Extraordinary School in Bandung. Three students are autistic and mentally disabled students. All three were chosen because they are in the same grade level. The research instrument was 20 questions that were tested during the pretest and posttest. The application of the Fisher-Yates and Fuzzy Sugeno algorithms is described as follows. Tables and figures are presented center, as shown below and cited in the manuscript.

2.1. Fisher-Yates algorithm

The Fisher-Yates algorithm used in this research is the modern Fisher-Yates algorithm. Following is a flowchart of the modern Fisher-Yates algorithm illustrated in Figure 1. From the flowchart in Figure 1, the following is an example of the Fisher-Yates randomization algorithm which is attached in Table 1. Educational games made there are three types of mini-games, namely quiz, rearrange, and matching. Fisher-Yates algorithm is applied to each mini-game to randomize the questions. The flowchart of the algorithm explained in Figure 1.

Table 1. Randomization of the Fisher-Yates Algorithm

Range	Roll	Scratch	Result
		A B C D E	
1-5	2	A E C D	B
1-4	1	D E C	A B
1-3	2	D C	C A B
1-2	1	C	E C A B
			D E C A B

Description
Range : Number of random objects
Roll : Roll: Position taken randomly to be exchanged
Scratch : List of numbers/objects during randomization
Result : Randomization results

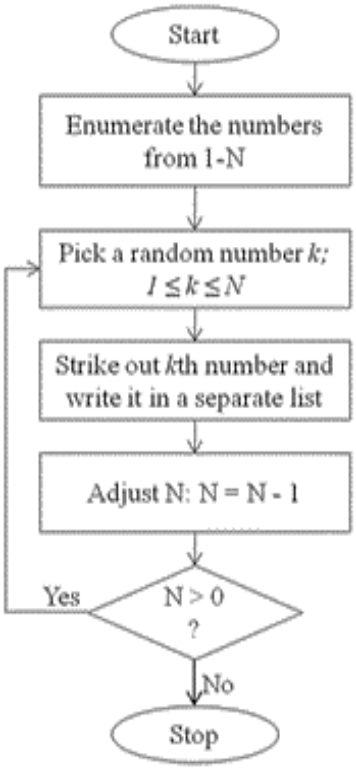

Figure 1. Flowchart of the modern Fisher-Yates algorithm [28]

2.2. Fuzzy Sugeno algorithm

In the game created, Fuzzy Sugeno algorithm is applied for scoring. Following is the design and calculation of the manual Fuzzy Sugeno algorithm which is applied to the Quiz mini-game.

- Fuzzy variable

In the system, two variables are used as input in the Fuzzy function, namely time (in seconds) and scores (in points). The output is a value (output - not including variables) as a star determinant. The two variables each have three fuzzy sets.

- Linguitic value

Of the two variables used, the linguistic values for the time variable are: fast, medium, and slow. Matches for Scores are: Large, Medium and Small.

- Fuzzification

Fuzzification is a mapping of crips (numeric) values into a fuzzy set and determines the degree of membership.

Time and Score are input, then operated with fuzzy logic based on fuzzy rules, after that conclusions can be drawn in the form of values. The value obtained will determine the number of stars the player gets. Based on the Fuzzy Interference System above, the following fuzzy set mapping.

a. The Time Variable (Second), the range as it follows. Time range is explained in the Figure 2.

- Fast (5-15), with the formula:

$$\mu\, FastTime[x] = \begin{cases} 1;\ x = 10 \\ \frac{15-x}{15-5}; 5 \le x \le 15 \\ 0; x \ge 15 \end{cases} \quad (1)$$

- Medium (10-40), with the formula:

$$\mu\, MediumTime[x] = \begin{cases} \frac{x-10}{25-10}; 10 < x \le 25 \\ \frac{40-x}{40-25}; 25 < x < 40 \\ 0; x \le 10\ or\ x \ge 40 \end{cases} \quad (2)$$

- Slow (30-50), with the formula:

$$\mu\, SlowTime[x] = \begin{cases} 1;\ x \ge 50 \\ \frac{x-30}{50-30}; 30 \le x \le 50 \\ 0; x \le 30 \end{cases} \quad (3)$$

b. The Score Variable (Poin), has the following range. The score range chart shown in the Figure 3.

- Small (0-50), with the formula:

$$\mu\, SmallScore[y] = \begin{cases} 1;\ y = 10 \\ \frac{50-y}{40-0}; 0 \le y \le 50 \\ 0; y \ge 50 \end{cases} \quad (4)$$

- Medium (20-80), with the formula:

$$\mu\, MediumScore[y] = \begin{cases} \frac{y-20}{50-20}; 20 < y \le 50 \\ \frac{80-y}{80-50}; 50 < y \le 80 \\ 0; y \le 20\ or\ y \ge 80 \end{cases} \quad (5)$$

- Large (50-100), with the formula:

$$\mu\, LargeScore[y] = \begin{cases} 1;\ y = 100 \\ \frac{y-50}{100-50}; 50 \le y \le 100 \\ 0; y \le 50 \end{cases} \quad (6)$$

c. Output

The value obtained is represented by the number of stars obtained.

- Very Good = 100, number of stars: 3.
- Good = 80, number of stars: 2.
- Enough = 50, number of stars: 1.
- Less = 25, number of stars: 0.
- Very Less = 10, number of stars: 0.

- *Fuzzy rule*

Nine fuzzy rules are used, will be described in tabular form. The following Table 2 is the fuzzy rules.

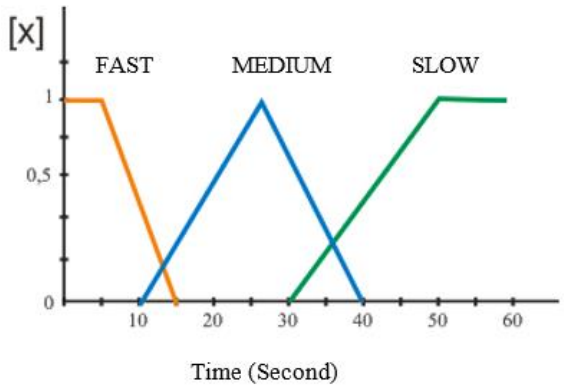

Figure 2. Time range chart

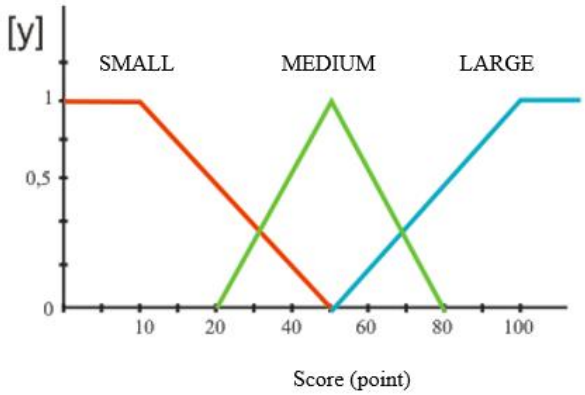

Figure 3. Score range chart

Table 2. The Fuzzy rules

ID	Rules
[R1]	If time = quick and score = big, then grade = good.
[R2]	If time = quick and score = medium, then grade = good.
[R3]	If time = quick and score = small, then grade = low.
[R4]	If time = medium and score = big, then grade = good
[R5]	If time = medium and score = medium, then grade = fair.
[R6]	If time = medium and score = small, is then grade = low.
[R7]	If time = slow and score = large, then grade = fair.
[R8]	If time = slow and score = up, then grade = fair.
[R9]	If time = slow and score = small, the grade = low.

3. IMPLEMENTATION

Implementation of the interface is the display interface when the game is run. Following is the implementation of the interface of the game made.

- Main Menu

The main menu is the main menu of the game. When the game starts playing, this display is the first thing that is displayed.

- Pet and Wild Animals Menu

When the player chooses a theme between Pet or Wild then the next display will enter the theme menu selected as shown in the Figure 4.

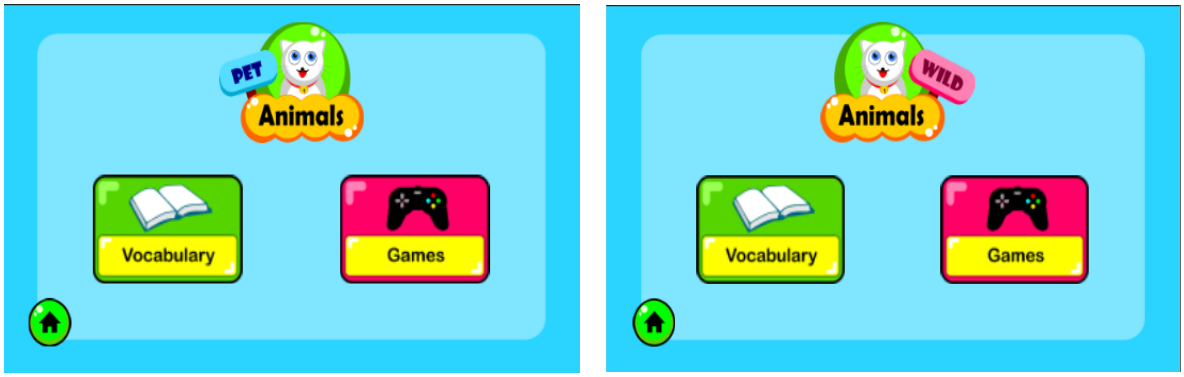

Figure 4. Pet (left) and wild animal (right) menu theme interface

- Vocabulary

When the player chooses the "Vocabulary" menu, a list of animals will appear. The interface of this menu shown in Figure 5.

Figure 5. Vocabulary interface

- Animal information interfaces

In the list of animals, the player selects one of the animals and animal information in the form of images, names in Indonesian and English will appear. Players can also listen to animal sounds by clicking on the picture. Besides, players can listen to English pronunciation of animal names by clicking on the speaker logo. The interface of this feature shown in the Figure 6.

Figure 6. Animal information interfaces

- Interface games for pet animals and wild animals

When the player selects the "Games" menu, the games sub menu will appear. Three mini-games can be played. When the player clicks on one of them, the selected mini-game starts. These three buttons are like the "Play" button. The game menu interface shown in Figure 7.

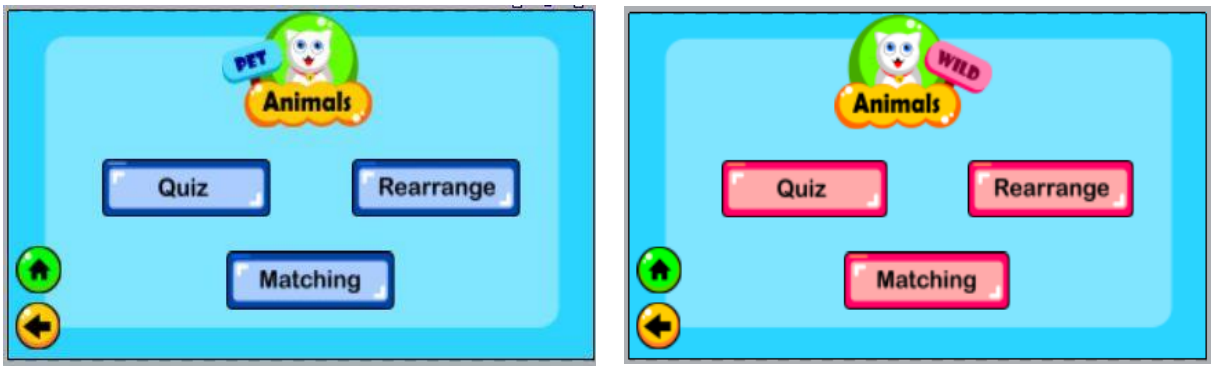

Figure 7. Games menu interface

- Interface quiz game pet animals and wild animals

Next is the display interface when playing quiz mini-games. Multiple choices in the form of images are clickable buttons as shown in Figure 8.

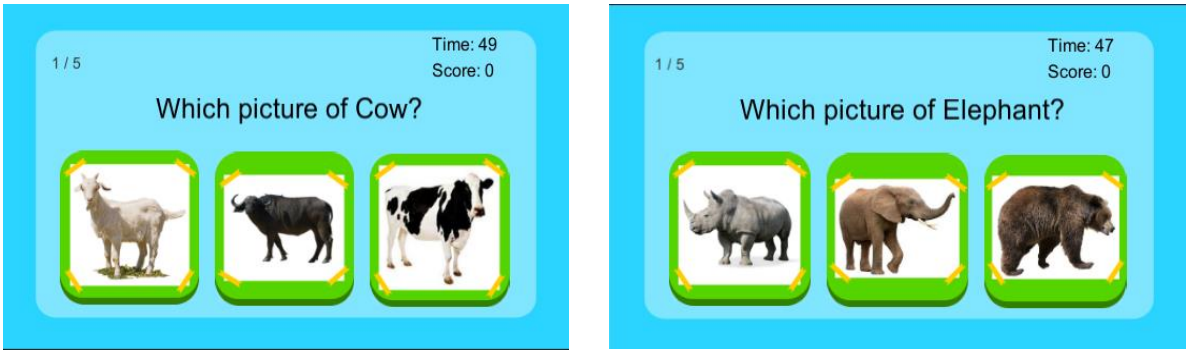

Figure 8. Quiz game interface

- Interface rearrange game pet animals and wild animals

The Figure 9 is the interface when playing rearrange mini-games. Blue bubble-shaped objects are objects that can be dragged and dropped onto gray circle objects.

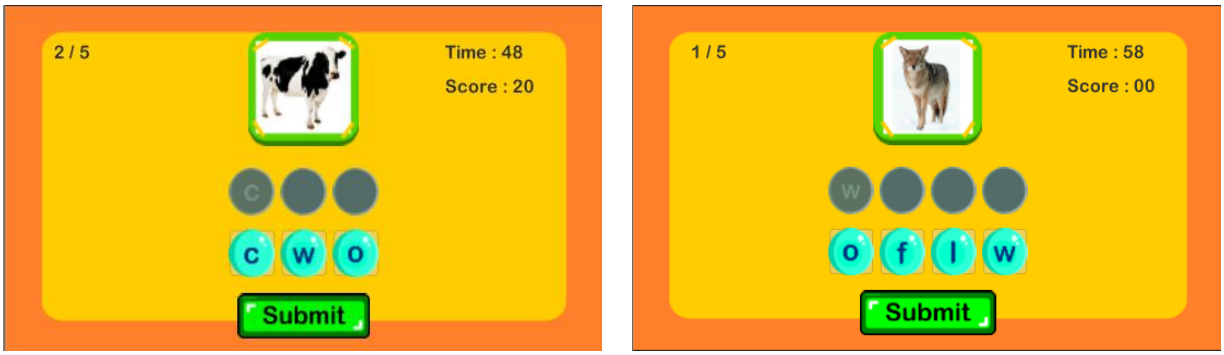

Figure 9. Rearrange game interface

- Interface matching game pet animals and wild animals

An object name in Figure 10 is an object that can be dragged and dropped onto the brown box object.

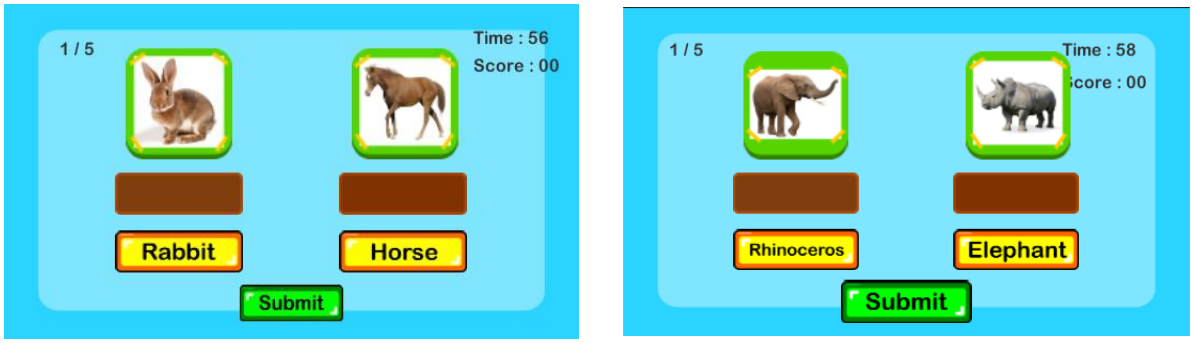

Figure 10. Interface matching game

- Interface finish playing

The finished playing interface depicted here is the general finished playing interface. The number of star points earned (1, 2, 3, or none) is adjusted according to the player's final score.

4. RESULT AND ANALYSIS

4.1. Fuzzy Sugeno testing

The experiment scenario is to play a quiz mini-game on the theme of pet animals. Players will complete the game within a range of 20-30 seconds, and get a score of 80 points by answering four questions correctly out of five. The experiment was carried out three times. Before testing is done on the game, testing is done on the testing system created (only executes the Fuzzy Sugeno algorithm) one time. In the testing system, enough time and points are inputted if only obtained. In this system also the time range and score can be changed. This test uses the same range as in manual calculations (time: 22 seconds, score: 80). The following results of tests conducted on the testing system illustrated in Figure 11.

Figure 11. Fuzzy Sugeno algorithm testing

Information:

1. Line 1 (0: 0.8: 0) is the fuzzification value of the set of time.
2. The second line (0: 0: 0.6) is the fuzzification value of the score set.
3. The 3rd line (0: 0: 0: 48: 0: 0: 0: 0) is the value of the aggregation/composition in the order of the rules.
4. The 4th line (0: 0: 0: 0.6: 0: 0: 0: 0) is the value of the results of the Fuzzy logic and Implications operation.
5. Line 5 ("*Nilai Kamu* = 80") is the result of deffuzyfication.

The picture shows that the results obtained are the same as for manual calculations. The game is completed in 22 seconds (maximum time is 50 seconds), gets 80 points, and the final score is 80 (gets three stars). Furthermore, testing is done on the game (on the mini-game quiz, the theme of Pet Animals). Tests carried out 10 times. The description of the screenshot is the same as the explanation described earlier. We tried testing the entire menu, and the following results were obtained in Table 3.

When compared to the results of manual calculations (time: 22, score: 80) which is getting a value of 80 and getting three stars, and the results of direct testing in the game (time range 20-30, score: 80) get a value of 80 as well and get three stars then it can otherwise the implementation of the Fuzzy Sugeno algorithm was successful, because the accuracy of the comparison of manual and system calculations was 100%.

Further explanation of system testing is that the time range of 20-30 is in the medium-slow linguistic variable, while the score 80 is in the medium-large linguistic variable. If seen in the rules, then:

[R3] IF Time is Medium and Score is Big, Then Grade is Good.
[R5] IF Time is Medium and Score is Medium then Grade is Enough.
[R7] IF Time is Slow and Score is large then Grade is Enough.
[R8] IF Time is Slow and Score is Medium then Grade is Enough.

The values are GOOD and ENOUGH, then the minimum value of the results from Fuzzy Logic Operations and Implications will be multiplied by 80 and 50 at the aggregation stage, so the values obtained from defuzzification around the range 80-100 and produce three stars.

Table 3. Fuzzy Sugeno test result

No	Input		Deffuzification Result	Output	
	Time	Score		Rating	Star
1	21.54163 (22)	80	80	80	3
2	21.20989 (21)	80	80	80	3
3	22.00988 (22)	80	80	80	3
4	19.65359 (20)	80	80	80	3
5	24.75888 (25)	80	80	80	3
6	22.76085 (23)	80	80	80	3
7	27.71176 (28)	80	80	80	3
8	26.19194 (26)	80	80	80	3
9	26.81919 (27)	80	80	80	3
10	28.46581 (28)	80	80	80	3

4.2. Fisher-Yates testing

The system has been tested 10 times on each mini game on one of the themes (pet animals) to see the next Fisher-Yates algorithm performance. Following are the results of randomization testing of each mini game shown in Table 4.

Table 4. Fisher-Yates testing result

1st Question	2nd Questions	3rd Questions	4th Questions	5th Questions
Which pict of Dog?	Which pict of Duck?	Which pict of Cat?	Which pict of Buffalo?	Which pict of Cow?
Which pict of Dog?	Which pict of Cat?	Which pict of Goose?	Which pict of Cow?	Which pict of Rabbit?
Which pict of Goose?	Which pict of Cock?	Which pict of Buffalo?	Which pict of Bird?	Which pict of Duck?
Which pict of Cock?	Which pict of Dog?	Which pict of Sheep?	Which pict of Goose?	Which pict of Duck?
Which pict of Dog?	Which pict of Cat?	Which pict of Goat?	Which pict of Horse?	Which pict of Bird?
Which pict of Duck?	Which pict of Cat?	Which pict of Rabbit?	Which pict of Fish?	Which pict of Buffalo?
Which pict of Rabbit?	Which pict of Horse?	Which pict of Sheep?	Which pict of Dog?	Which pict of Fish?
Which pict of Buffalo?	Which pict of Duck?	Which pict of Rabbit?	Which pict of Horse?	Which pict of Cow?
Which pict of Rabbit?	Which pict of Cock?	Which pict of Duck?	Which pict of Cat?	Which pict of Goose?
Which pict of Sheep?	Which pict of Cow?	Which pict of Fish?	Which pict of Buffalo?	Which pict of Cat?

The questions that appear every game are random, so it can be stated that the implementation of the Fisher-Yates algorithm was successful because the level of accuracy with manual randomization is 100%. Next, the system has been tested 10 times on each mini-game on one of the themes (pet animals) to see the next Fisher-Yates algorithm performance. Following are the results of randomization testing of each mini-game shown in Table 5.

Table 5. Fisher-Yates testing result (summary)

No	Input	Expected Result	Remarks
1	10 times the gameplay in the game quiz.	Random question	Success
2	10 times gameplay in a rearranged game.	Random question	Success
3	10 times gameplay in matching games.	Random question	Success

4.3. Student understanding test result

The game was tested on three junior high school grades, namely H (15 years), J (14 years), and F (13 years). H and J are special needs students who are mentally disabled, while F is a child with autism. The sample was selected based on the quasi-experimental method using the existing group which in this case is an ordinary class.

The research design used in this study is the one group pretest post-test design, which is a form of research design in a quasi-experimental method.Testing of this educational game is carried out in the order given the pre-test questions first, followed by the use of the application, and after that a post-test (the same problem with the pre-test). The following results of the study, seen from the average scores of the three children in the pre-test and post-test, are attached in Table 6.

Table 6. Pre-test and post-test result

Average Pretest Score	Average Post-test Score
80.41	88.3

From the acquisition of the pretest and posttest results, a difference of 7.89 points shows an increase in student understanding after playing the game. This can be interpreted that the game can increase students' understanding of pet and wilds material.

5. CONCLUSION

An English learning game called pet and animal game has been designed. Educational game created has been tested directly on Special Children Needs students with applied Fuzzy Sugeno and Fisher-Yates algorithm in the game. Fuzzy Sugeno algorithm is suitable for concluding data that are not too complex, including scoring games to determine the score in Pet and Wild Animal educational games that only use two variables. Fisher-Yates algorithm can be used as one of the shuffle algorithm randomization problems because of the short execution time, does not use a large amount of memory, and produces balanced randomization. The game has proven can improve students' understanding of animal recognition material, as seen from the increase in the average score from pretest to posttest by 7.89 points.

6. FUTURE WORKS

The future application of the Fisher-Yates algorithm can be applied to the randomization of letters in similar mini rearrange or quiz games. Learning material can also be made deeper and more complex.

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