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# English Education Game using Non-Player Character Based on Natural Language Processing

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**Abstract**

Game education is a game that aims for educational and entertainment. But the educational game is not popular to users. Therefore, it takes innovation and other ways to improve the educational game itself. Based on the current user survey, games that have dynamic elements such as artificial intelligence are sufficiently requested by users. For this reason, this study aims to build educational games that implement artificial intelligent (AI). In a game, AI is often implemented as Non-Player Character (NPC). The method used for NPCs in this game is based on the Natural Language Processing approach. This is so that the NPC can answer questions about English automatically. The results show that the educational game that has this NPC gets an average score above 75% of users. In addition, users also provide positive feedback on the game itself apart from the questionnaire. So it can be concluded that the presence of NPCs in educational games can increase user interest. With this new approach, it is hoped that it can also increase the popularity ranking of the educational game genre.



*Keywords:* Educational Game; Non-Player Character; Natural Language Processing; User Assessment

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## 1. Introduction

Currently, the game is very popular both among children and adolescents. According to Federation of American Scientist and EU kids Online Network, Children spend one to two hours playing games every day [1]. As well as when children use the internet, reports show that the second activity is playing game after completing homework [2].

Game developers realize the potential of utilizing their entertainment value by offering learning content during gameplay [3]. This has created a game that has the genre of "Serious Game" which incorporates elements of wealth, role-playing, atmosphere-based stories to teach, train, and change knowledge, attitudes, and behavior [4]. On the other hand, Serious Games have also been used in various domains, such as the military, government, education, companies, and health. This shows that the game has the potential to provide an impact on users, especially for user education [5]. Based on the literature survey, Serious Games which are the most used by researchers are educational games [6]. But in reality, educational games are less attractive to users than other game genres such as action games.

In addition, there are also many games that have artificial intelligence (AI) and computational intelligence in a game. According to Georgios [7], AI games are games that change methods, processes, and algorithms in the intelligence that will be applied to game development and development. He mentioned that there are three panoramas in the AI game, namely the perspective of the method (computer), the perspective of the user (human) and the perspective of player interaction. In AI games, Dagsthul [8] also mentioned there are ten types of AI games. In addition, there is also research on educational games that utilize the similarity method [9]. This shows that artificial intelligence and computational intelligence are often used in most games with interdependent interactions with players. So that AI has an important role to play in increasing user interest in playing games.

From the description above, we assert that applying elements of artificial intelligence into the educational game will increase the user's interest in the educational game itself. So that this study address to analyze the assessment or feedback from users on the development of educational games that use Non-Player Character (NPC). Besides that, the NPC that was built also applied the Natural Language Processing (NLP) method to be able to answer questions automatically. And this study only focuses on analyzing user ratings because the NPC method that will be applied has been made in our previous research [10].

## 2. Natural Language Processing

Language is an arbitrary sound system, which is used by a community to communicate, interact, cooperate, and identify themselves. Each Language must have grammar or grammar rules in the formation of writing especially for English. English is an international language that has many grammar rules such as each sentence formation must pay attention to pronouns, nouns, verbs, adjectives, adverbs, prepositions, determinants, and conjunctions.

In technology development, there is a computer system science that studies or examines how to understand natural language writing where there is a meaningful interaction between computer and human in an application field [11]. This science is commonly called Natural Language Processing (NLP). In the NLP research, many suggested a method for forming a writing on various languages such as English. One of them was the NLP group from Stanford University researching the processing of English and making supporting software [12]. In the formation of English sentences, the NLP method usually refers to the basic rules of grammar, i.e. each sentence must consist of at least one subject and one verb. Table 1 Shows the form of label or part of speech (POS) used in the NLP process taken from Penn Treebank [13].

Table 1. POS English Keyword and Tagging in Natural Language Processing.

| Tag | Description | Example |
|---|---|---|
| CC | conjunction | and, but, or |
| DT | determiner | a, the |
| EX | existential | there |
| IN | preposition | of, in, by |

| Tag | Description | Example |
|---|---|---|
| JJ | Adjective | yellow |
| JJR | Adjective comparative | bigger |
| JJS | Adjective superlative | biggest |
| MD | modal | can |

| Tag | Description | Example |
|---|---|---|
| NN | Noun singular | Ilama |
| NNS | Noun plural | Ilamas |
| NNP | Proper noun singular | IBM |
| NNPS | Proper noun plural | Carolinas |
| PDT | Pre-determiner | all, both |
| Tag | Description | Example |
| PRP | Pronoun | I, you, he |
| PRPS | Possessive pronoun | your, one's |
| RB | Adverb | quickly |
| RBR | adverb comparative | faster |

| Tag | Description | Example |
|---|---|---|
| RBS | adverb superlative | fastest |
| RP | Particle | up, off |
| SYM | Symbol | +,%,& |
| VB | verb base form | eat |
| VBD | verb past tenses | ate |
| VBG | verb gerund | eating |
| VBN | verb past participle | eaten |
| VBP | verb non-3sg pres | eat |
| VBZ | verb 3sg pres | eats |

## 3. Design and method

### *3.1. Menu design*

In this educational game, there are two menus that are Main Menu and Battle Menu. Main Menu is the start menu used by the user to select the game level. While Battle Menu is the core game menu where users can play or fight against NPC or enemies. Once the user completes the game, it will go to the Result Menu which displays the feedback result of the user game. In the Result Menu, there is a history of the number of questions and the number of answers answered correctly by the user. After that, the user will return to the Main Menu and can select the game level again. Relation about menus in this game is shown in Fig. 1.

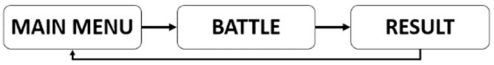


Fig. 1. Flow of Menu Design in Game.

### *3.2. Level design*

Each level of the game has the same components and paths which differ only at the level of difficulty of the problem. Each level contains a battle game between players and NPCs in clashing answers to English Grammar questions. For those who answer faster, then he will attack first. As well as character strength will increase if the character can answer the questions correctly. But on the contrary, if the character answers incorrectly the character strength will be reduced. The game will end when Health of one of the characters has run out. In this game, Fig. 2 shows about ten levels which have different difficulty.

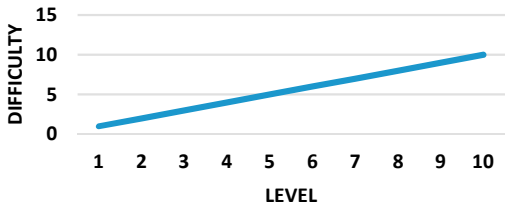


Fig. 2. Level difficulty in each level.

### 3.3. Non-Player Character method

This educational game is using Non-Player Character (NPC) to increase interesting aspect for the user. NPC system is build based on Natural Language Processing Theorem. NPC in this game can answer the English question automatically. There are several steps for NPC to answer the question. First, NPC read the English question and answer option in gameplay. Next step, NPC will process the learning method to get the answer. In the learning step, NPC tokenizes the question into one text and put in vector. Then this vector will be done in the POS Tagging step to get the label for each term. After labeling, the blank sentence will check to grammar rule based on label and sequence of the vector. From this step, NPC gets the label for a blank word in the sentence and can answer the question based on the choice option. This process will be repeated until the game over. This process is shown in Fig. 3.

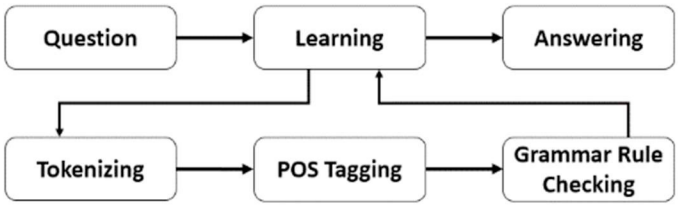


Fig. 3. Non-Player Character method in educational game.

### 3.4. Data

Data for this game is consist of 100 English questions from Longman TOEFL Test Books by Philip Deborah. This question is a multiple-choice form and has two until four choice option. This data is used for gameplay in Battle game between user and NPC. Each level has ten questions which level one until five is easy to question and level six until level ten is a hard question. The example of this question is shown in Table 2.

Table 2. The average value of users for educational game.

| No | Question | Answer |
|---|---|---|
| 1 | I … so sad. | am |
| 2 | I … an apple. | have |
| 3 | We … the comedian. | are |
| 4 | It …. Empty. | is |
| 5 | He …hiking yesterday. | was |

## 4. Result and Discussion

The educational game is tested on several users to get ratings and feedback. This is because the game must be related to the user. In addition, because the question of English implemented in the game is a matter of grammar, this game has a wider target and many people. This is because not everyone controls English grammar. In fact, there are still many people who already have students who do not necessarily have a higher TOEFL score than those who are still in high school. So that this English education game can be used and is useful for all groups, especially students. This game can be accessed on BlogSpot with the address http://turtletrainer.blogspot.com. The interface of this game is shown in Fig. 4 and Fig. 5.

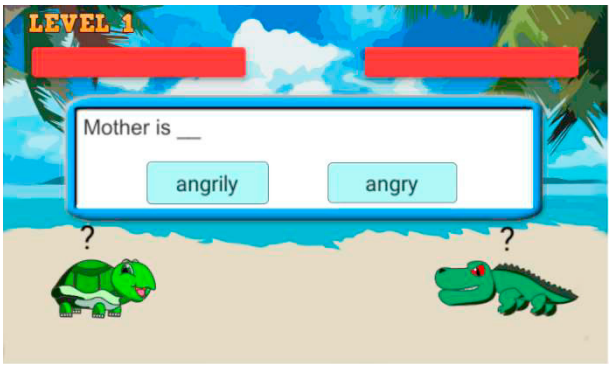


Fig. 4. Interface of Battle Menu.

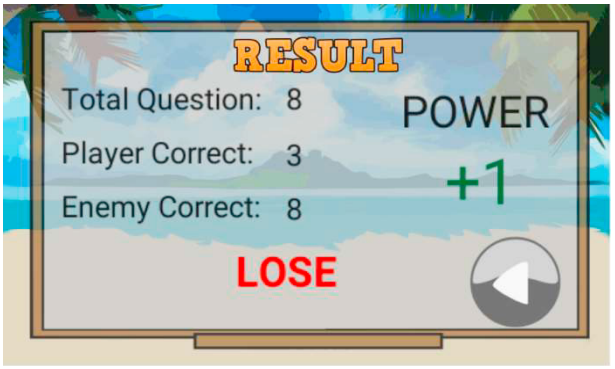


Fig. 5. Interface of Result Menu.

The game application is tested by 27 users who have aged 21-25 years old. Broadly speaking, the questions for this study are based on three characteristics of assessment which are shown in Table 3. And added to one characteristic of valuation is the overall value or rating according to the user. A more detailed list of questions is shown in Table 4. Each question is part of the three characteristics of the assessment. Each questionnaire question has a value range of 1 to 10 wherein general the value of 1 means very bad and the value of 10 is very good. Then the values obtained from all users are averaged to produce the final value of each assessment characteristic. The questionnaire is given to the user not only via directly but also via online using google spreadsheet.

Table 3. The average value of users for educational game.

| Assessment Characteristic | Average of Result Value |
|---|---|
| Game Design and Architecture | 7,38 |
| AI / NPC Perform | 7,53 |
| Educational material and system | 7,83 |
| Overall value from user (Rating) | 7,71 |
| Average | 7,61 |

Table 4. List of questionnaires for users.

| Assessment Characteristic | Assessment Sub-Characteristic | Questionnaire |
|---|---|---|
| Game Design and Architecture | Usability | The ease of playing the game |
| | Game Design | The beauty and aesthetics of the interface |
| | User Interface | Level of user interaction in the game |
| | User Experience | The level of user experience playing the game |
| | Usefulness | The level of usefulness of the game |
| | User Satisfication | User satisfaction with the game |
| | Motivation | Game influence on user motivation |
| | Enjoyment | A level of fun or fun when playing games |
| | Acceptance | Acceptance level for game system design |
| | | The level of acceptance of the level of difficulty level in the game |

| Assessment Characteristic | Assessment Sub-Characteristic | Questionnaire |
|---|---|---|
| AI / NPC Perform | Performance | The level of accepting the question in the game |
| | | The level of smoothness of the game process |
| | | Animation in the game |
| | | Intelligence level of AI or enemy in answering questions. |
| | | How fast is AI in answering questions |
| Educational material and system | Understandability | Understanding of educational values in the game |
| | Motivation | The effect of education in the game on you |
| | | Effect Helps in understanding English grammar lessons |
| | Acceptance | Conformity of educational material with difficulty level |
| | Learning Outcomes | Interest in learning English lessons |
| | | Does the game make you more aware of English material? |

Table 3 is shown that the four assessment characteristics have a value of more than seven. Characteristics of game design and architecture assessment get a value of 7.38 score. The characteristics of this assessment are direct user-focused assessments. Judgments are taken based on the behaviour and thoughts of users according to their experience, abilities, interests, and interactions with the educational game. This value shows that the game is worthy of being a game with the Battle genre in general without emphasizing its education. But this also shows the game is not maximal. One of the feedbacks obtained about the characteristics of this assessment is the need to be improved regarding interactions and appearance. Because this educational game still has 4 main screens. This causes the games that have been built yet to have complex gameplay. So that there needs to be an improvement in future research to improve the design and architecture of this English language educational game.

The second characteristic of the assessment of the performance of artificial intelligence. This characteristic focuses on the performance of artificial intelligence in the game. In addition to the assessment and trials described earlier, this study also requires an assessment of AI from the user's side in observing the performance of AI. The results show the characteristics of this assessment get a value of 7.53 score. This value is higher than the architecture and game design evaluation characteristics. This shows that the user considers and concludes that the AI performance is good. In question, the user is directed to provide assessors in terms of the accuracy and speed of AI in interacting specifically in answering questions about English.

The value obtained also shows that the AI built with this method is sufficient according to the intelligence of the user. Although basically, AI's performance is not smart enough to answer all the questions. AI can only answer questions with standard abilities such as for someone who has the average ability in the field of English grammar. Feedback given by users, in general, is the process of answering AI too quickly. In the educational game, the AI that was built can answer questions about English in only 4-5 seconds. But in fact, AI can answer questions quickly. So that in the future AI must be reset to have a delay coefficient to slow down speed so that it matches the user's speed. Besides that, in terms of animation, the character also needs to be improved to make it more varied and smoother.

As well as the characteristics of the third assessment regarding educational material. The educational value obtained has a value close to 8-unit numbers which are 7.83 scores. The characteristics of this assessment focus on the user's assessment of the material and education system in the game. The value obtained shows that the educational role in the game has hit the user. The material given is also in accordance with the level of difficulty of the level where levels one to five are easier questions than levels six to ten. The user also concluded that the English grammar questions given had usefulness and impact on the learning side. But the feedback is given also lacks that it should be a dynamic setup problem. This means that the questions have to be randomized so that users who play do not memorize the questions. So, the questions must be added and set dynamically to be done in the next study.

The final evaluation characteristic is the overall assessment according to each user. This overall value can consist of all the parameters in it. Each user has their own opinion in assessing the educational game as a whole. This value acts as a rating for published applications or games in the online marketplace. So that it only has one-unit value to give an assessment. The results obtained have a value of 7.71 scores. This shows that the game that was built already has a rating that is worthy of publication. If converted to a range of one to five, the rating obtained is worth more than three stars. So that the user has concluded that, this English education game has been good for dissemination among the student community. The average results of the four assessment characteristics have a value of 7.61 units of numbers. This value is more than 7.5 units of numbers. This means that the English education game has good quality assessment characteristics. But there is a need for development in further research both in terms of architecture, design, artificial intelligence, educational materials, and so forth to get a higher value. This user research is an additional trial in this study in addition to core trials. So, the results of this user trial can also be used as valid evaluations in this study. As well as research this user can also provide information to other researchers or game developers in developing in the realm of artificial intelligence in educational games.

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## References

[1] Scientists, Federation of American. (2006) "Harnessing the Power of Video Games for Learning", in *Summit on Educational Games*.

[2] Livingstone, S., and L. Haddon. (2009) "EU Kids Online: Final Report." *LSE: EU Kids*.

[3] T. Sitzmann. (2011) "A Meta-Analytic Examination of The Instructional Effectiveness of Computer-Based Simulation Games." *Personnel Psychology* **64**: 489-528.

[4] Garris, R., R. Ahlers, and J. E. Driskell. (2002) "Games, Motivation, and Learning: A Research and Practice Model." *Simulation and Gaming,* **33**: 441–467.

[5] Castellar, E. N., J. V. Looy, A. Szmalec, and L. d. Marez. (2014) "Improving Arithmetic Skills Through Gameplay: Assessment of The Effectiveness of an Educational Game in terms of Cognitive and Affective Learning Outcomes." *Information Sciences* **264**: 19-31.

[6] Yunanto, A. A., and S. Rochimah. (2017) "Systematic Literature Review Toward Software Evaluation in Serious Game." *Jurnal Informatika*.

[7] Yannakakis, G. N., and J. Togelius. (2015) "A Panorama of Artificial and Computational Intelligence in Games." *Computational Intelligence and AI in Games* **7 (4)**: 317-335.

[8] Lucas, S. M., M. Mateas, P. S. M. Preuss, and J. Togelius. (2012) "Artificial and Computational Intelligence in Games." *Dagstuhl Reports*, **2:** 43-70.

[9] Yunanto, A. A., D. Herumurti, and I. Kuswardayan. (2018) "Artificial Intelligence of Educational Game for English Learning Based on Similarity Heuristic Approach." *Jurnal Sistem dan Informatika (JSI).*

[10] Yunanto, A. A., D. Herumurti, I. Kuswadayan, and S. Rochimah. (2018) "Intelligent System for Agent in Educational Game Using Dynamic Gram Similarity," in *2018 International Seminar on Application for Technology of Information and Communication*, Semarang.

[11] Tucker, A. B. (2002) "Overview of NLP: Issues and Strategies", *Bowdoin College*. Available from: http://www.bowdoin.edu/~allen/nlp/nlp1.html. [Accessed 26th Septermber].

[12] Stanford NLP Group. (2016) "The Stanford Natural Language Processing Group", *Stanford University.* Available from: http://nlp.stanford.edu/. [Accessed 1st October].

[13] Manning, C. n.d. *Part-of-speech Tagging: A Simple But Useful form of Linguistic Analysis.*