



Android-Based *Statistics Adventure* Educational Games to Enhance Students' Understanding of Measures of Central Tendency and ICT Literacy

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Abstract

In the era of society 5.0, one of the essential skills students must possess is ICT literacy. This skill can be developed through the use of technology-integrated learning media. One of the technology-based learning media that can be used is educational games. This study aims to examine the effectiveness of the *Statistics Adventure* educational game in enhancing students' understanding of measures of central tendency and ICT literacy. The ICT literacy components assessed include access, manage, integrate, evaluate, and create. This research specifically focuses on the "create" component. Data were collected using questionnaires, interviews, and tests. The participants were 28 seventh-grade students from SMP Negeri 3 Jember. The results show that the *Statistics Adventure* game is effective in enhancing students' ICT literacy, with an overall N-Gain score of 0.8, categorized as high. The N-Gain values for each indicator are as follows: access (0.84), manage (0.87), integrate (0.84), evaluate (0.72), and create (0.92), with "create" showing the highest gain. Furthermore, the game is also effective in enhancing students' understanding of the subject matter, with an N-Gain score of 0.5. These findings suggest that educational games can significantly enhance both ICT literacy and content comprehension among students.

Keywords: Android-based Educational Game; *Statistics Adventure*; Measures of Central Tendency; ICT Literacy; Mathematics Learning.

Abstrak

Kemampuan yang perlu dimiliki siswa pada era society 5.0 saat ini adalah kemampuan literasi ICT. Kemampuan literasi ICT dapat dicapai melalui penggunaan media pembelajaran yang memanfaatkan teknologi. Salah satu media pembelajaran berbasis teknologi yang dapat digunakan adalah game edukasi. Penelitian ini bertujuan untuk menguji efektifitas penggunaan game edukasi *Statistics Adventure* untuk meningkatkan pemahaman siswa tentang materi pemusatan data statistika

dan literasi TIK. Aspek ICT meliputi Access, Manage, Integrate, Evaluate, dan Create. Pada penelitian ini aspek yang akan diteliti adalah aspek create. Model pengembangan yang digunakan adalah ADDIE terdiri dari lima tahap yaitu *Analyze* (Analisis), *Design* (Desain), *Development* (Pengembangan), *Implementation* (Implementasi), dan *Evaluate* (Evaluasi). Metode pengumpulan data yang digunakan adalah angket, wawancara, dan tes. Subjek penelitian ini adalah siswa kelas VII SMP Negeri 3 Jember sebanyak 28 siswa. Keefektifan *game* edukasi *Statistics Adventure* efektif untuk meningkatkan *ICT Literacy* siswa dengan nilai N-Gain yang diperoleh sebesar 0,8 sehingga efektif dengan kategori tinggi. Nilai N-gain setiap indikator menunjukkan peningkatan, *Access* (0,84), *Manage* (0,87), *Integrate* (0,84), *Evaluate* (0,72), dan *Create* (0,92). Aspek Create merupakan aspek dengan nilai N-Gain tertinggi. Berdasarkan hal tersebut dapat disimpulkan bahwa *game* edukasi dapat meningkatkan *ICT literacy* siswa dengan kategori tinggi. *Game* edukasi ini juga efektif untuk meningkatkan pemahaman siswa dengan nilai N-Gain sebesar 0,5.

Kata Kunci: Permainan Edukatif berbasis Android; Petualangan Statistika; Tendensi Sentral; Literasi TIK; Pembelajaran Matematika.

Introduction

The world is currently entering the era of Society 5.0, “a concept introduced by Japan to describe a future society characterized by advanced technological integration. According to Nur et al., (2022), Society 5.0 is an evolution of the Industry 4.0 era. While Industry 4.0 emphasizes the use of artificial intelligence and automation, Society 5.0 focuses on integrating technology with human-centered values. This era certainly influenced the world of education. One of the key issues is students’ low interest in reading, which contrasts sharply with their increasing use of the internet and digital media. Therefore, the integration of technology in education is essential to enhance students’ understanding of learning materials and to help them fully experience the benefits of technology in the learning process.

The technology can be utilized as learning media. Technology in learning can increase student’s enthusiasm for learning and understanding the content better (Nurdyansyah & Riananda, 2016). This is in line with research conducted by Syfanii et al., (2023) which states that ICT-based learning media can be a solution to learning in this era. The use of ICT-based learning media makes it necessary for students to have ICT literacy skills so that the use of technology can support student learning activities. The application of ICT literacy in learning activities can support students in fulfilling their academic responsibilities, as the use of technology facilitates more efficient and accessible learning. Based on the Regulation of the Minister of Education and Culture Number 37/2016 about the implementation of ICT learning that focuses more on the ability of students to operate computer and internet devices than on the ability to analysis and process information obtained online (Hidayanti, 2021).

ICT literacy is the skill of using telecommunications equipment or digital technology and to utilize as a means to access, manage, integrate, evaluate, and create information (Educational Testing Service (ETS), 2002). Aspect create is producing information by applying, designing, creating, or making information. According to Febrianti & Susilowati (Fatahillah et al., 2023) students' ICT literacy skills can be achieved through innovative learning media that utilizes technology as a learning effort for students so that optimal learning occurs in students to anticipate the direction of development of science and technology. One of the learning media that can be used by utilizing technology is educational games. According to Nilwan (Saputra & Handani, 2015). A game is a structured activity and can also be used as a learning tool. According to Hikam (Kurniawan & Risnani, 2021) educational games are games that are used to stimulate students' thinking in increasing concentration and making it easier for students to improve their understanding of the material. Educational games are specifically designed to teach the student (user) a certain learning, concept development, and understanding, and guide them in practicing their skills as well as motivating them to play it (Setiarini, Margunayasa, & Rati, 2024).

Educational games can be operated on various platforms, one of the most commonly used being the Android operating system. Android is an operating system on smartphones that is in demand at this time. Android is an operating system that is widely used because it has features that are easy for users to understand. Android is an operating system for Linux-based mobile devices that includes information systems, applications, and middleware. Android has an open-source concept so that users can freely develop their own version of the Android system. Android-based educational games can be used in learning math. Mathematics is an abstract science, full of symbols, and structures in its solution (Malikah et al., 2022). The subject matter in mathematics that is considered difficult is statistics material. This is supported by research conducted by Dewi et al., (2020) which shows that students have difficulty solving statistics problems because students have not been able to understand the basic concepts of statistics, communicate problems by modeling mathematics, performing statistical manipulations, and drawing conclusions. Students are still difficult in solving statistics problems, the difficulties experienced by students are in understanding the concepts of mean, median, and mode, and difficulty in applying the mean, median, and mode formulas to the data presented in table form.

The educational game that will be produced in this research is called "Statistics Adventure". As the name implies, this game has an open-world adventure genre where players will take an adventure through the map that has been provided. Contains 3 islands in accordance with statistical material and has a different place setting on each island. The number of zombies in the game is statistical data used to calculate the mean, median, and mode. Players can switch from FPS (First Person Shooter) mode to TPS (Third Person Shooter) mode. This "Statistics Adventure" educational game is assisted by Unity software. According to Finnegan (Mekel, Sompie, and Sugiarto, 2019) Unity is a 3D game builder application that allows the creation of 2D games. Unity is a game engine that has many features such as GUI (Graphic User Interface), Audio, Animation, Effect, Scripting, Game Object, and supported programming languages such as C# and JavaScript. The advantages of Unity are that it can be used with the internet or without connecting to the internet, can make games with several modes such as FPS and TPS, and can make games that can be played for Mac, Wii, Windows, IOS, Android, and many more.

Based on the description described above, researchers will develop an educational game "Statistics Adventure" based on Android utilizing Unity software on class VII junior high school statistics material to enhance students' understanding of statistical material about measures of central tendency and ICT literacy. The implementation of this research is supposed to enhance students' understanding of measure of central tendency and ICT literacy by using the "Statistics Adventure" educational game.

Method

This type of research is development research that aims to develop educational games that are valid, practical, and effective in improving students' understanding of measuring central of tendency and ICT literacy. This development model is the ADDIE model which consists of five stages which is Analyze, Design, Development, Implementation, and Evaluation. The Analyze stage consists of 3 analyses, namely (a) Performance analysis, to find out what learning media have been used at schools, (b) Needs analysis, to find out what learning media are needed, (c) Curriculum analysis, aims to find out what curriculum is used at school. At the design stage, data collection is carried out, making flowcharts and storyboards. At the development stage, realize what has been made at the design stage to become an initial product which will then be validated. At the implementation stage, students were tested. Before students play the educational game, students fill out a

questionnaire containing ICT literacy questions to know the ICT literacy skills of students before using the game. After finishing playing the game, students fill out a questionnaire related to ICT literacy to find out the ability of ICT literacy of students after using educational games. At the evaluation stage, educational game revisions are made based on suggestions from students during implementation activities. The test subjects were VII-I grade students of SMPN 3 Jember as many as 28 students.

The research instruments include a validation sheet, ICT literacy questionnaire, user response questionnaire, interview guidelines, student learning test results, and observation guidelines. The practicality of the educational game is obtained from the user response questionnaire. An educational game is considered effective when the average percentage result from user response questionnaires shows a very good or good category (Kristiana, Fatahillah, & H, 2022). The good or not category of an educational game can be seen in Table 2.

Table 1. Practicality Percentage Category

Value	Validity Level
$P > 95\%$	Very good
$80\% < P \leq 95\%$	Good
$65\% < P \leq 80\%$	Good enough
$50\% < P \leq 65\%$	Not good
$P \leq 50\%$	Very bad

The ICT literacy questionnaire serves to see students' habits in using ICT and their interest in using ICT. ICT questionnaires are self-made according to the game to be developed and validated before being given to students. interviews are used to obtain in-depth information about a person's understanding, skills, and ICT experiences after using educational games. To obtain data related to students' ICT Literacy, the instrument used is an ICT Literacy questionnaire given before and after using educational games. This questionnaire is prepared in accordance with ICT literacy indicators which consist of five aspects, namely access, manage, integrate, evaluate, and create. The ICT literacy indicators that have been modified in accordance with the educational game to be developed can be seen in Table 3.

Table 2. Modified ICT Literacy Indicators

Components ICT Literacy	Indicator
Access	• Opens the educational game • Accessing the user manual
Manage	Learning the menu and buttons in the educational game

Components ICT Literacy	Indicator
Integrate	Combine the information obtained from the game instructions and game introduction to play the educational game.
Evaluate	Selecting one key of value according to the prompt and instructions
Create	Use the information about statistics obtained after using the educational game by taking the post-test

Then the results of the ICT literacy questionnaire were analyzed by calculating the total average before and after using the educational game and then looking for the N-Gain value to determine the increase in student ICT literacy. An educational game is declared effective for increasing ICT literacy if the g value is in the medium category or $g \geq 0.3$. To obtain the N-Gain value, the following formula can be used.

$$N - Gain(g) = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}}$$

Information

$N - Gain$	=	The normalized gain
$S_{posttest}$	=	Skor posttest
$S_{pretest}$	=	Skor pretest
S_{max}	=	Skor maximum ideal

N-gain value criteria categories can be seen in Table 4.

Table 3. N-Gain Value Categories	
Value of g	Categories
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

According to (Ermawati, Sarjana, Baidowi, & Sridana, 2021) the assessment of students' mathematics learning outcomes will be analyzed using classical learning completeness. There are 2 criteria for effectiveness in this indicator, namely learning completeness $\geq 85\%$ of all students who are complete and positive student responses to learning using statistics adventure games.

Results

This research used the ADDIE development model which has five phase which is analyze, design, development, implementation, and evaluation stages. The first stage is the analysis phase (analyze), during which three types of analyses are conducted, namely: (a) Performance analysis, based on observations and interviews, it is obtained information that schools have utilized ICT in learning activities and interactive media that have been used include canva, google slides, and worldwall, (b) Needs analysis, based on observations and interviews, schools have never used downloaded android-based educational games as learning media, (c) Curriculum analysis, the curriculum used by schools is the Merdeka curriculum. The Merdeka Curriculum also encourages a project-based learning approach, which allows students to be more involved in the learning process through practical experiences (Farid, Putri, Rahmah, Putra, & Nisa, 2024) . The Merdeka Curriculum presents the Proyek Penguatan Profil Pelajar Pancasila (P5) which aims to provide opportunities for learners to learn in a fun and flexible way, and develop various competencies required in the Profil Pelajar Pancasila (Mery, Martono, Halidjah, & Hartoyo, 2022). Therefore, the utilization of technology is relevant and urgent to be integrated into learning activities. All material components in the educational game are made in accordance with the curriculum.

In the design stage, data collection is carried out in the form of material selection, learning outcomes, and formulating learning objectives. The statistic material used in the "Statistics Adventure" educational game is 7th grade statistics material consisting of average (mean), median, and mode. At this stage, the flowchart and storyboard are also made. The main menu display consists of instructions for use, audio settings, and start playing. The start-playing view consists of tutorials, start playing the average island, start playing the median island, and start playing the mode island. When the player chooses the play island button, the game instructions will appear before starting to play and if they have read all the instructions, the educational game display will appear. Players must shoot all the zombies in all the villages on the island. Players who have shot all the zombies will be faced with selecting a key. The key contains numbers related to the number of zombies and the number of villages or cities or parks. Players who choose the key correctly can open the gate and continue the adventure to the next island while if the player chooses the wrong key, then the player's life will run out and must start the adventure from the beginning. At the development stage, the flowchart and storyboard are realized into an initial product. The educational game development process used Unity 3D software. The assets used in making this educational

“Statistics Adventure” game are downloaded on the unity asset store. The display of the “Statistics Adventure” educational game can be seen in Figure 2 to Figure 5.



Figure 1. Home Menu “Statistics Adventure”



Figure 2. Island Selection Display



Figure 3. Game Display When Start Playing



Figure 4. Mission to Choose Key Display

At this stage, the educational game was validated by validators consisting of two lecturers of Mathematics Education at University Jember and one mathematics teacher at SMPN 3 Jember. Educational game validation consists of three aspects, namely content aspects, format aspects, and linguistic aspects. Suggestions and revisions from validators can be seen in Table 4.

Table 4. Suggestions and Revisions

Suggestion	Before Revision	After Revision
Add statistics material at the beginning before starting the game	None	

Suggestion	Before Revision	After Revision
Improve the educational game display so that it is not too monotonous		

The results of the validity test recapitulation can be seen in Table 5.

Table 5. Validation Average Value

Aspect	Average
Content	3,8
Format	3,6
Linguistic	3,8

According to the information presented in the table above, it can be concluded that the "Statistics Adventure" educational game developed obtained an average score of 3.7 which indicates that the "Statistics Adventure" is valid with a very high category level so that games can be used to enhance students' understanding measure of central of tendency and ICT literacy. The ICT questionnaire was also validated by validators. The validation results show that the ICT questionnaire is valid with an average value of 3.65 which indicates that the ICT questionnaire is valid with a very high category and can be used to measure student literacy. In terms of assessment, if the subject answers 'Yes', then the students will get a score of 1, while for the answer 'No', the students will get a 0.

The following stage is the implementation stage. During this stage, the educational game is validated which has been declared valid by the validator. The trial was conducted at SMPN 3 Jember, with the participants consisting of 28 seventh-grade students from class VII-I. The implementation was carried out to assess how well educational games work. The results of the analysis of the practicality of educational games are obtained from the educational game user response questionnaire. The user response questionnaire consists of 10 indicators. Based on the results of the calculation of the user response questionnaire, it was found that 83% of the 28 students gave a positive response so the "Statistics Adventure" educational game was declared practical with a good category. Results of students' responses can be seen in Table 6.

Table 6. Result of Student's Response

No	Aspect	Avg
1	I can open the main page of "Statistics Adventure" easily	3,15
2	I can understand the instructions for using "Statistics Adventure"	3,39
3	I can understand statistics material more easily with this "Statistics Adventure"	3,24
4	I feel happy learning using this "Statistics Adventure"	3,57
5	I have an interest in learning to use this "Statistics Adventure"	3,39
6	The language used is clear	3,33
7	Selection of appropriate colors	3,27
8	I understand the problems stated in educational games	3,33
9	I am motivated to learn statistics material using "Statistics Adventure"	3,27
10	I use this "Statistics Adventure" as a learning aid	3,33

Based on the student's response questionnaire, students were more dominant in giving positive responses, namely with an average of 3 and 4. If students predominantly give choices 4 or 3, then it can be said that the response given by user to the learning media that has been developed is positive (Irawan & Hakim, 2021). Based on this it can be concluded that Statistics Adventure is practical because students can play it anywhere and anytime without the internet. The results of the analysis of the ICT literacy questionnaire before and after using educational games show that there is an increase in student ICT literacy with the average value of the questionnaire before using educational games is 0.5 and the average value of the questionnaire after using educational games is 0.9. Based on this data, it was found that the N-Gain value of the ICT literacy questionnaire was 0.8 so the educational game was declared capable of increasing student ICT literacy in a very high category. The average value of the ICT literacy questionnaire before and after using educational games can be seen in Figure 5.

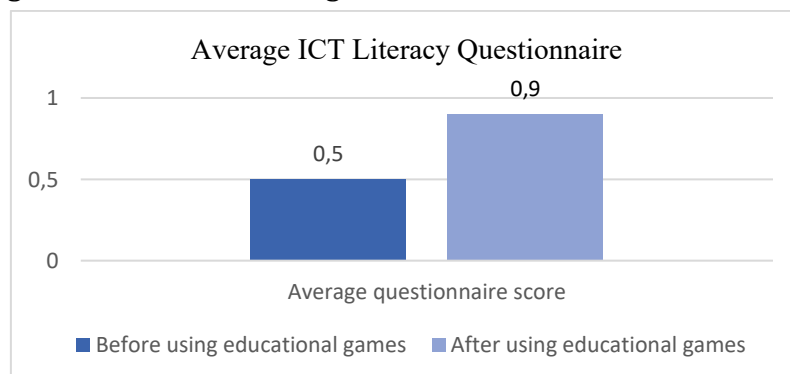


Figure 5. Average Score of ICT Literacy Questionnaire

The results of the ICT literacy questionnaire were also analysis using SPSS and the N-Gain results were obtained as follows.

Table 7. N-Gain Calculation Results using SPSS

Descriptive Statistics					
N Gain Pretest- Post test	N	Minimum	Maximum	Mean	Std. Deviation
	28	0.00	1.00	0.8455	0.24949
Valid N	28				

Normality test was also conducted as a prerequisite test of paired sample t-test. The results of the normality test of the ICT literacy questionnaire can be seen in Table 8.

Table 8. ICT Literacy Questionnaire Data Normality Test Results

ICT literacy questionnaire results	Grade	Kolmogrov-smimov		
		Statistics	df	Sig.
	VII-I	0,154	28	0,087

Based on the results of the normality test calculation above, it shows that the sig value. $0.087 > 0.05$ so that the data is normally distributed. After calculating the prerequisite test, the next step is to do the t-test. The paired sample t-test results can be seen in Table 9.

Table 9. Paired Sample T-Test Results

Paired Differences									
Pair 1	Pretest- Posttest	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of The Difference		t	df	Sig.
					Lower	Upper			
		-38,89	19,67	3,71	-46,52	-31,26	-10,46	27	0,000

Based on Table 7 above shows the results of the Paired Sample T-test test on the Sig value. (2-tailed) is of $0.000 < 0.05$, this shows that there is a difference in the average ICT Literacy questionnaire before and after using educational games. Based on this, it can be concluded that there is an effect of using Statistics Adventure educational games on improving students' ICT literacy skills.

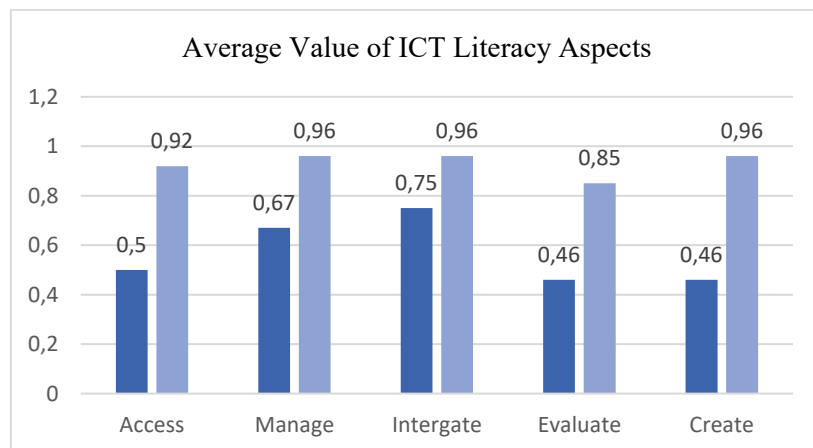


Figure 6. The Average Value of ICT Literacy Aspects

According to Figure 6, the knowledge indicator regarding create shows the greatest n-gain value which is 0,92 so it falls into the high category. N-gain value aspect access is 0,84, manage is 0,87, integrate is 0,84, and evaluate is 0,72. The create aspect consists of one indicator, namely using information about statistics obtained after using educational games by doing a post-test. This is supported by the results of the student learning test where the post-test results showed that 85% of students or 24 out of 28 students met the complete category. A descriptive analysis of test results can be seen in Table 10.

Table 10. Descriptive Statistics Test Results

	N	Minimum	Maximum	Mean	Std. Dev
Pretest	28	30	100	64.29	22.962
Posttest	28	30	100	82.32	17.611

The final stage in this research is the evaluation stage. Educational games that have been tested at the implementation stage will be made final revisions according to criticisms and suggestions from users. Based on the interview results, some buttons on the tutorial cannot be pressed and the jump button in the game can be pressed continuously so that the player can fly. Then a revision was made according to this, the jump button was made into a button that could be pressed only when the player was standing and landing. After making revisions, educational games are distributed in the SMPN 3 Jember environment and can be accessed or downloaded by anyone through the following link <https://unej.id/StatisticsAdventureGames>

Discussion

The *Statistics Adventure* educational game was implemented to enhance students' ICT literacy. Students responded positively to the game, indicating that it provided an engaging and enjoyable learning experience. The game was particularly effective in making the learning of statistical concepts more interesting and interactive. This is supported by research conducted by Wibawa et al., (2020) which states that educational games generally combine aspects of games and material making the material more interesting to learn. The educational game "Statistics Adventure" also improved students' ICT literacy (see Figure 5). Improvement occurred in all aspect of ICT literacy (see Figure 6) including access, manage, integrate, evaluate, and create. Relevant research conducted by Fatahillah et al., (2023) which produced an android-based "Math Trip" educational game on the material of revival which showed that the educational game developed met the criteria of valid, practical, and effective, and was able to increase student ICT literacy in the high category with an N-Gain value obtained of 0.88. As a result of this, when students engage in educational games, they learn how to use the buttons effectively within the games, integrating and applying the knowledge they gain. This is also in line with research conducted by Anwar (2022) producing an android-based "Adventure of Prop" educational game on comparison material showing that educational games meet the criteria of valid, practical, and effective for increasing student ICT literacy in the high category with an N-Gain value of 0.75.

The higher N-Gain research results compared to previous studies can be caused by several factors. One of the causes is the use of learning media that is more interesting and effective. Another factor that may play a role is an increase in students' understanding of the learning material, which can be measured through higher pretest and post-test scores. Based on the result above, to measure the effectiveness of ICT literacy, apart from using questionnaires, you can also use the results of statistical learning tests. Every student must use ICT's efficiently to enhance learning outcomes (Menggo & Ndiung, 2024). By concentrating on the advantages of ICT integration in the classroom, students' motivation and learning output can improve, leading to advanced and innovative learning (Wiranda & Ciptaningrum, 2024).

The create aspect is the aspect that has the highest n-gain value compared to other aspects. At each island in the games, the student gains information about means, median, and modus of data. After students defeat all the enemies in the game, students are asked to choose one of the keys to open the gate where the enemy is used as data. If they choose the wrong key, the student must repeat the level. The repetition process can make students better to understand the material (Fatahillah,

Alfiyantiningasih, & Dafik, 2021). This is also supported by the results of the student learning test where the post-test results showed that 85% of students or 24 out of 28 students met the complete category and the N-gain value is 0,5. Three out of four students who did not complete still experienced an increase in their post-test scores while the remaining 1 student's scores remained the same or did not increase. Based on the results of the interview with the student, the student was unable to use the information in the game because the student lacked understanding in solving statistical problems whose problems were different from the example problems in the educational game. The N-Gain value obtained was 0.5 so educational games were declared effective. The create indicator is still able to measure in-depth understanding of statistical material because 27 out of 28 people's pretest results still increased. This increase in learning outcomes shows that educational games can help communicate or provide information on mathematics learning concepts efficiently and have a positive impact on learning outcomes.

Conclusion

The development of the educational game "*Statistics Adventure*" followed the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. Based on these stages, it can be concluded that the "*Statistics Adventure*" game is highly valid, with an N-Gain score of 0.92; practical, with a usability percentage of 83%; and effective in improving students' ICT literacy, with a high category N-Gain score of 0.80. For future researchers interested in similar studies, the "*Statistics Adventure*" game can be further developed by incorporating additional statistical topics such as range, quartiles, interquartile range, standard deviation, and other relevant statistical concepts.

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