The Waste Sorting Education Media: An Innovation with Android-based Game

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A R T I C L E   I N F O
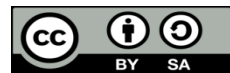
A B S T R A K

Pengetahuan mengenai klasifikasi dan pemilahan sampah sangat penting mengingat saat ini Indonesia merupakan salah satu negara penyumbang sampah plastik terbesar di dunia. Permainan yang dapat dimodifikasi untuk tujuan edukasi adalah permainan edukatif khususnya dalam memilah sampah. Penelitian ini bertujuan untuk mengembangkan game edukasi pemilahan sampah berbasis android (dengan jenis-jenis sampah yang muncul di lingkungan sekolah), serta cara memilah sampah berbasis android tersebut. Permainan edukasi sangat tepat dijadikan sebagai media edukasi atau pembelajaran. Peneliti menggunakan desain penelitian dan pengembangan atau Research and Development Design (R&D) dengan model Borg and Gall. Pada penelitian awal ini dilakukan sampai pada tahap uji coba pengguna skala kecil. Pengumpulan data respon guru sebagai pengguna media dilakukan dengan menggunakan instrumen kegunaan aplikasi yaitu System Usability Scale (SUS). Penelitian dilakukan di 4 sekolah dasar. Game edukasi Memilah Sampah ini dikembangkan menggunakan Construct 3, Canva dan Pixlr. Permainan ini dioperasikan dengan ponsel pintar berbasis Android sehingga mudah diakses oleh masyarakat luas. Hasil uji validitas ahli media dan ahli materi menunjukkan bahwa hasil permainan edukasi Pilah Sampah berbasis Android sangat valid sehingga sangat layak digunakan sebagai media edukasi siswa sekolah dasar.

A B S T R A C T

Knowledge of waste classification and segregation is very important considering that currently Indonesia is one of the largest plastic waste contributor countries in the world. Games that can be modified for educational purposes are educational games, especially in waste sorting. This study aims to develop an android-based waste sorting educational game (with the types of waste that appear in the school environment), as well as how to sort this android-based waste. Educational games are very appropriate as educational or learning media. Researchers use a research and development design or Research and Development Design (R&D) with the Borg and Gall model. In this initial study, it was carried out up to the small-scale user trial stage. The collection of teacher response data as a media user is carried out using an application usability instrument, namely the System Usability Scale (SUS). The research was conducted in 4 elementary schools. The educational game Sorting Trash was developed using Construct 3, Canva and Pixlr. This game is operated with an Android-based smart phone so that it is easily accessible to the wider community. The results of the validity test by media experts and material experts show that the results of the Android-based Sort Waste educational game are very valid, so they are very suitable for use as educational media for elementary school students.

1. INTRODUCTION

The era of rapid technological development requires us to adapt more quickly in an effort to adapt to the times. One of the rapid developments in technology is the rapid exchange of information that occurs with the implementation of an increasingly fast and massive internet, electronic commerce, electronic data interchange, virtual offices, telemedicine, and other implementations of information exchange. All implementations of rapid and massive communication have an impact on the views of the public, who are also happy with the fast and easy exchange of information that occurs. So, we all always make it easy to carry out our daily activities with this technology (Fatimah & Santiana, 2017; Henita Rahmayanti et al., 2020). Sometimes, the convenience provided by the rapid development of information exchange and

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massive development also has an impact on natural resources. The virtual life provided by the internet makes humans and people tend to be lazy and tend to decide things instantly. This is due to the lack of human ability to protect natural resources directly. It is undeniable that currently there are many problems that occur in nature, such as water pollution, soil pollution, and forest damage caused by consumptive behavior and human lifestyles. In addition, environmental problems that arise are pollution (water, soil and air), increasing global temperatures, global climate change, and decreasing the diversity of biological and natural resources (Haleem et al., 2022; H. Rahmayanti et al., 2020). This is reinforced by data on environmental pollution, one of which is caused by waste left over from public consumption. Especially for waste, national waste generation in 2021 is 31.13 million tons and in the Central Java region it reaches the highest national figure of 5,614,155.21 tons (Hoffmann & Pfeiffer, 2022). In 2022 the total waste generation in Indonesia will reach 19.4 million tons and in Central Java there will be 21.85% of Indonesia's waste generation, namely 4.25 million tons of waste (Satria et al., 2021).

This environmental problem must be overcome with countermeasures (direct action) and preventive action in the form of providing environmental education. Environmental Education is part of efforts to foster, develop and increase knowledge, skills, attitudes and actions of individuals, groups, organizations and various parties on environmental issues for the sake of sustainable development for present and future generations (Bastian et al., 2020; Widiyatmoko et al., 2022). Each school is responsible for delivering environmental education materials and building the character of loving the environment and solutive character to solve existing environmental problems. Until now, waste is the most urgent problem to be solved. Garbage has taken over land and even water areas. Too many places or locations have been used as Final Disposal Sites, and waste has also polluted river and sea ecosystems. The concept of sorting waste is not optimal, waste should be separated based on the specified category. However, community behavior in the field in sorting waste is still not optimal. So that more socialization and education is needed to increase awareness, behavior and culture of sorting waste. Delivering waste sorting education to school members, especially students, must be made more attractive so that the community and school members understand the importance of sorting waste for the common good (Bastian et al., 2020; Mariyanti, 2023).

Knowledge of waste classification and segregation is very important considering that currently Indonesia is one of the countries with the largest plastic waste contributor in the world. Continuous and excessive use of plastic waste can result in water and soil pollution, air pollution, flood hazard, disrupting food chain processes and global warming or climate change. All of these problems are certainly very threatening to the sustainability of the sustainable development that we are working on together. So everyone must understand at least how to sort waste so it doesn't mix with plastic waste. The simple classification is classifying waste into non-biodegradable waste, difficult-to-decompose waste, and easily decomposed waste (Amasuomo & Baird, 2016; Yustriani & Zulfiani, 2023). The dissemination of educational delivery regarding waste management does not have to be done in a conventional way, namely by displaying powerpoints and explaining theoretically how to process and sort waste. One way of effective delivery is by packing it with a game. Games that can be modified for educational purposes are educational games. Currently, educational games are in great demand as an alternative in delivering material to convey various contents of learning materials by providing challenges, rewards, and punishments in game design (Kartini & Putra, 2020; Qohar et al., 2021; Sari et al., 2017). Educational games are also in great demand by the majority of Generation Z, because they use very complex technology. As we all know, Generation Z is very good at mastering technology. Educational games can stimulate students' minds and creativity. Educational games can create a lively, safe and fun playing environment so as to improve the quality of children's learning. Educational games increase the player's logic and understanding of the information he gets when using the game. So, with game design in waste material it can stimulate student creativity and innovation (Ayu & Gayatri, 2023; Insani Nurchintyawati, 2022).

Previous research has developed educational games that students can use to create a different learning atmosphere and make students the center of learning (Widiyatmoko et al., 2022). An educational games to improve science learning outcomes about the classification of living things. In addition, an educational game that taught how to sort organic and inorganic waste and the results of recycling inorganic waste. In another study an educational game was produced to sort organic, inorganic and hazardous waste using Adobe Photoshop and Adobe Illustrator which had a positive impact on students, namely increasing proficiency scores in using Adobe Photoshop and Adobe Illustrator (Uska et al., 2021; Wardani et al., 2017). The difference between this research and other research is the development of Android-based educational games. In previous research, the development of device-based educational games. The purpose of this study was to develop of an android-based waste sorting educational game (pilah trash) which contains the most common waste sorting content in the school environment. In

addition, this study also aims to explain the feasibility test of the Sorting Waste educational game. This article emphasizes how to develop an android-based waste sorting educational game (with the types of waste that appear in the school environment), as well as how this android-based waste sorting educational game is appropriate as an educational or learning medium.

2. METHOD

Researchers use a research and development design or *Research and* Development Design (R&D) with Borg and Gall models. In this initial research, it was carried out up to the small-scale user trial stage. The stages carried out in this development research from potential research and problems, data collection, product design, design validation, design revision, product trials, product revision, small-scale usage trials (Akker et al., 2013; Sugiyono, 2015). The research was conducted in 4 elementary schools in Klaten, Central Java. Potential and problem research was conducted by interview, observation and literature study. Interviews were conducted with teachers, principals, school janitors and the Adiwiyata School Development team from the local Environmental Agency. Development was conducted with the subject of 4th grade elementary school students. The validity testing team was elementary school teachers, a team of media experts, a team of material and language experts. Data from the validation of the expert team and teachers as media users were processed with quantitative and qualitative analysis. Data collection of teacher responses as media users was carried out using the application usability instrument, namely the *System Usability Scale* (SUS). The validity category of learning media is guided by the learning media categorization in the Table 1.

Table 1. Learning Media Validity Categories

No	Interval	Kategori
1	RTV>3.25	Highly Valid
2	2.49<RTV≤3.25	Valid
3	1.74<RTV≤2.49	Less Valid
4	0.99<RTV≤1.74	Invalid

Data analysis of SUS instruments using predetermined formulations, as odd numbered questions (1,3,5,7 and 9) each answer score is reduced by 1. For even numbered questions (2,4,6, 8 and 10), the score is 5 minus the score of the answer to that number. The SUS score of one respondent is the sum of all scores from all numbers and then multiplied by 2.5. The results of the calculation of the usability score or value with SUS are interpreted in the *Acceptable* Range as show in Table 2.

Tabel 2. *Acceptable Range* SUS Score

SUS	Meaning
0-50,9	*Non Acceptable*
51-70,9	*Marginal*
71-100	*Acceptable*

Scores can also be interpreted with reference to the *Acceptable* Scale is show in Figure 1.
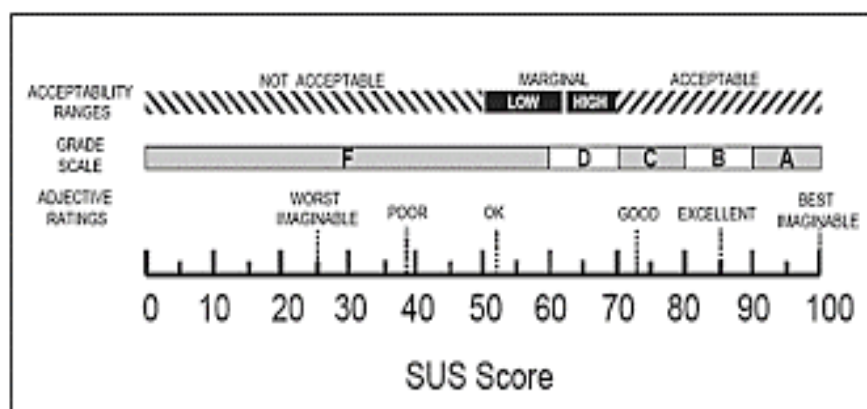
Figure 1. Acceptable Scale SUS Score

3.   RESULTS AND DISCUSSION

Result

This research uses a research and development (R&D) design with 10 steps of development research according to the model developed by Sugiyono. The first stage is research on the gap between theory and reality, in addition to taking data on the background problems and the potential that can be utilized to solve existing problems. The background of environmental problems, especially waste and student behavior towards waste generation in the school environment. Based on the researcher's interview with the janitor, students have not been able to implement waste sorting behavior. The results of interviews with teachers and grade 4 and the head of SD Muhammadiyah Tonggalan Klaten, education about sorting waste has been carried out using the lecture method. The Adiwiyata school supervisor team of the local Environmental Agency gave instructions that the waste generation in schools was quite a lot, especially in the types of paper, plastic and organic waste from plants and food scraps. In this preliminary research, researchers also conducted a literature study on methods, learning or educational media that are in accordance with the character of students at this time. Researchers found in previous studies that practical games that are in accordance with the current times are starting to be used as learning or educational media. The second stage carried out in this research is planning and designing the design of educational media development that focuses on sorting waste with the subject of elementary school students. The selected waste-sorting educational media is educational media in the form of an Android-based game called the Sorting Trash game. The design stage begins with making a flowchart and then a storyboard. Furthermore, based on the storyboard and flowchart that has been made, an Android-based Sorting Trash educational game prototype is designed using Construct 3 game developer tools, Canva and Pixlr for image asset processing. The following design is developed in storyboard as show in Figure 2.
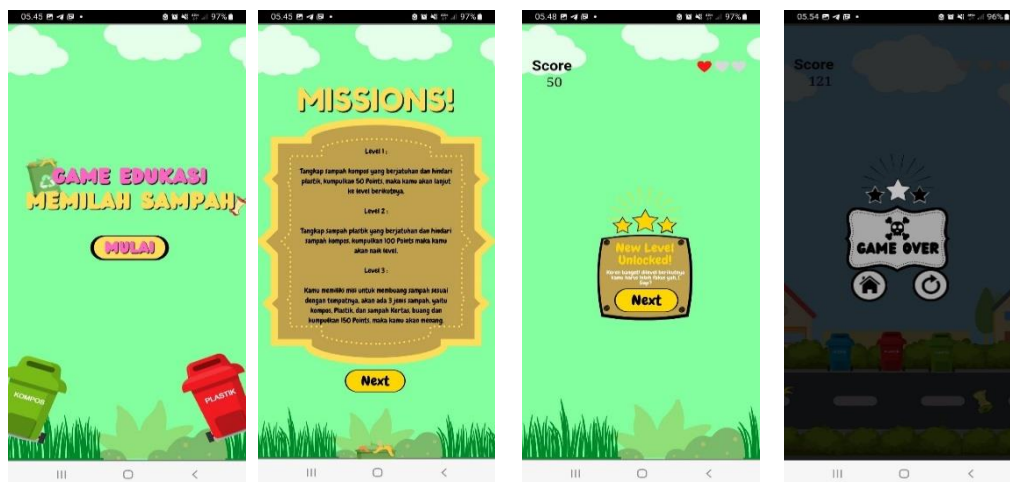
Figure 2. Storyboard of Sorting Trash Education Game

The storyboard will be processed with Construct 3 and put together with music ornaments and interfaces, so that it becomes a unified game that has a flow. The third stage is the design validation test by media and material experts. The following are the results of the Sorting Trash educational game validation test by media experts and material experts is show in Table 3.

Table 3. Recapitulation of Media Expert Validation Results

No	Criteria	Ai
1	Display design	3.50
2	Media quality	3.43
3	Suitability with educational objectives	3.33
4	Accessibility	3.44
	RTV	**3.43**

Based on Table 3, the Average Total Validation (RTV) value of the media is 3.43 and based on the learning media validation category in Table 1, the results of the validity test by the Sorting Trash educational game media experts include the RTV>3.25 category which means "very valid". In the validity test of the Sorting Trash educational game, the testers provided recommendations for improving the game

from various parts. Input and suggestions from experts to improve the performance and work of the Sorting Trash educational game to make it more effective to use. Recapitulation of material expert validation results is show in Table 4.

Table 4. Recapitulation of Material Expert Validation Results

No	Criteria	Ai
1	Conten elibibility	3.48
2	Presentation feasibility	3.67
3	Language feasibility	3.52
4	Contextualized assessment	3.67
	RTV	**3.58**

Based on Table 4, the RTV value of the material is 3.58. This figure based on the validation category shows a very valid category. In addition to the numerical assessment, the material validation team also provided suggestions and qualitative assessments of the material in the Sorting Trash educational game. Suggestions or corrections from the material expert are then used as a reference to improve game content that is still not appropriate to increase the effectiveness of the Sorting Trash educational media. The revised design with the recommendations of the expert team was then tested on one group of users, namely teachers. The results of the trial use of the Sorting Trash educational game with the SUS instrument is show in Table 5.

Table 5. Recapitulation of SUS Respons

No	Respondents	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total	Value (Quantity x2,5)
1	Responden 1	4	3	4	3	4	3	3	3	4	3	34	85
2	Responden 2	4	4	4	4	3	4	4	4	4	4	39	98
3	Responden 3	3	4	4	3	3	4	4	4	3	3	35	88
4	Responden 4	3	3	4	3	3	3	4	3	4	3	33	83
5	Responden 5	4	4	4	4	4	4	4	4	4	4	40	100
6	Responden 6	4	4	4	4	4	4	4	4	4	3	39	98
7	Responden 7	3	4	4	4	3	4	3	4	4	3	36	90
8	Responden 8	3	4	4	4	3	4	4	4	4	1	35	88
9	Responden 9	3	4	4	4	4	4	4	4	4	3	38	95
10	Responden 10	3	3	4	3	3	3	3	3	4	3	32	80
11	Responden 11	4	3	4	3	4	3	4	3	4	3	35	88
12	Responden 12	3	3	4	3	3	3	4	4	4	1	32	80
13	Responden 13	3	3	4	3	3	3	3	3	3	3	31	78
14	Responden 14	4	4	4	4	4	4	4	4	4	4	40	100
15	Responden 15	4	4	4	4	4	4	4	4	4	3	39	98
16	Responden 16	4	4	4	4	4	4	4	4	4	4	40	100
17	Responden 17	4	4	4	4	4	4	4	4	4	4	40	100
18	Responden 18	4	4	4	3	3	4	4	4	4	3	37	93
19	Responden 19	4	4	4	4	4	4	4	4	4	4	40	100
20	Responden 20	3	4	4	3	3	3	4	3	4	3	34	85
21	Responden 21	4	3	4	3	4	3	4	3	4	4	36	90
22	Responden 22	3	3	3	3	3	4	4	4	4	3	34	85
23	Responden 23	3	4	4	4	3	4	3	4	4	3	36	90
24	Responden 24	3	4	4	4	3	4	4	4	4	1	35	88
25	Responden 25	4	4	4	4	3	4	4	4	4	4	39	98
26	Responden 26	3	3	3	4	3	3	4	4	3	4	34	85
27	Responden 27	4	4	4	4	4	4	4	4	4	4	40	100
28	Responden 28	3	4	4	4	3	4	4	4	4	3	40	93
29	Responden 29	3	4	4	4	4	4	4	4	4	3	38	95
30	Responden 30	3	3	4	3	4	3	4	3	4	3	34	85
		104	110	118	108	104	110	115	112	117	94		
	Average score (Final Result)												91

Base on Table 5 the results of the trial with the SUS instrument on the responses of 30 teachers showed a score of 91. Based on Table 2, this value shows the status of "acceptable" or accepted. Based on Figure 1, this means that the media is in grade A and "best imaginable".

Discussion

The potential of play in learning thus reinforces the urgency and challenge of developers and educators to acquire practical tools in a variety of subjects that demand visualization, such as in building space materials, and are easy for students to use. Visualization has a positive impact on learning. The Sorting Trash educational game was developed using the Construct 3 Game Development tools, namely 2D game development without coding so that developers don't need to understand coding. We design by drag and drop (Batubara, 2017; Fauzi et al., 2021). Construct 3 was chosen by researchers because the working system is relatively easy compared to other game development tools and there is no need to download it on a computer before using it. Developers only need logic and an understanding of interfaces and features in developing games (Febriyanti et al., 2023; Lastari & Silvana, 2020). Images or assets or objects in educational waste sorting games are processed using Pixler and Canva to produce images that are attractive and true to their original form even though they are in animated form. Besides that, in this educational game Sorting Garbage, researchers added sound effects. Influence on the game is one thing that attracts students to learn with the game. In accordance with its purpose, the Sorting Waste game is a type of educational game according. This medium is interesting and unique. Game-based learning is attractive to children, especially digital natives, educational games are formed from a combination of designs with interesting, interactive elements and most importantly, they contain certain curriculum content (Hanifah et al., 2022; Singh. & Prasad Singh, 2021). Sorting Garbage Game is designed with a 3+ rating category, meaning that this game is designed for children aged 3 years and over so that it is very safe for children to use because it does not contain violent or pornographic content.

The gameplay in the Sorting Garbage educational game consists of three levels, at the first level the player has to collect 10 points from the task of catching organic waste to a trash can with organic writing. If you catch non-organic waste (plastic and paper waste), "life" will decrease. The symbol of life is depicted with three red heart assets. After reaching 10 points, the player will enter the second level. In the second level, the player has to collect 10 points by catching plastic waste. "Life" will be reduced if the player catches organic and plastic waste in plastic type bins. After a total score of 20 and "lives" are still there, the player can enter the last level or the third level. In the third level, the player has a mission to put three types of waste (paper, plastic and organic) into the proper bins by dragging or dragging the trash image assets to the appropriate bins. Players will win if they have collected a total of 30 points. This game provides educational information about the behavior of disposing of garbage and sorting it by type so that it can be reprocessed (Amir et al., 2019; Jazuli et al., 2018).

The test results of media experts on the Pilah Garbage educational game on display design criteria are 3.50, media quality is 3.43, the suitability of educational goals is 3.33 and accessibility criteria is 3.43. RTV value is 3.43. The value of all criteria based on the categorization of learning media shows a very valid category. The results of the material expert test on content feasibility were 3.48, presentation feasibility was 3.67, language feasibility was 3.52 and contextual assessment was 3.67. Based on the categorization of learning media, the results of the assessment on each criterion show a very valid category. Based on validity tests by a team of media experts and material experts, revisions were made to the consistency of the Indonesian language, interface information, scoring, level switching bugs but not disturbing the game and trash assets (Fadella et al., 2018; Lai et al., 2020). Meanwhile, revisions were made to the material regarding waste terms, image size, variations in waste samples. One of the material experts stated that game material is suitable for use without revision.

The transmission of waste management instructional delivery does not have to be done in the traditional fashion, namely by presenting powerpoints and theoretically describing how to process and sort garbage. Packing it with a game is one successful method of distribution. instructional games are games that may be customized for instructional purposes (Piotrowska et al., 2022; Rafique et al., 2020; Rohmah & Bukhori, 2020). Currently, educational games are in high demand as a means of conveying diverse learning materials by including challenges, incentives, and punishments into game design. Educational games are also popular among the majority of Generation Z, owing to their usage of sophisticated technology. As we all know, Generation Z is quite adept at using technology (Kartini, Ketut Sepdyana., Putra, 2020; Kuswanto & Radiansah, 2018). After revisions were made based on the recommendations of media experts and material experts, a test was then carried out with SUS on users, in this case 30 elementary school teachers. Based on the results in Table 5, the score of the SUS test for the educational game Sorting Waste is included in the "Acceptable" game category or accepted by the user. In the results of the SUS usability test, the scores on the 10 SUS instruments show varying total scores. The

score for each question item was converted using the SUS score conversion formula. The highest total score is in question three which contains the ease of using the Waste Sorting educational game application. The total score shows 118 for 30 respondents, the average respondent's answer is on a scale of 4 (strongly agree). This shows that the educational game Sorting Waste is very easy for its users to operate. The Waste Sorting Game was developed to be operated using an Android-based gadget or smartphone, so it is easy for most people to use. The second highest total score is the total score on item nine out of 117 with the average respondent's answer on a scale of 4 (strongly agree). Question number 9 contains the respondent's level of trust in using this educational media to sort waste. Based on the Acceptable Scale the results of the SUS usability test from the Pilah Garbage educational game with user respondents, namely teachers, indicate that this educational game is on scale A, namely "Best Imagination" or the best game available.

Another research conducted EPGBL was effective in increasing students' conceptual understanding and environmental awareness (Ardani et al., 2020; Kuswanto & Radiansah, 2018). The average percentage of correct answers in the pre-test was 61.33, while the percentage of correct answers in the post-test was 73.33. These results indicate that the percentage of correct answers in the post-test is higher than the pre-test. In the combined tier the percentage of correct answers shows that students really understand the concept of environmental pollution. Whereas in the questionnaire analysis it was revealed that after using EPGBL, students were more concerned about the character of caring for the environment. The average value of students' environmental care character is 3.98 which is included in the good criteria. Based on the research that has been done, suggestions that can be given are that researchers can add a variety of educational games related to environmental pollution material, and game-based learning media can be developed for other materials in learning science in junior high school. Other research also states that android-based applications are very feasible to use in terms of content regarding waste with a percentage of 85%. Furthermore, in terms of the appearance/design of the application that we made, we got a score of 83% (very decent), and users have a very high response category from the usability aspect (83%), so that users feel that this application is easy to understand, easy to use, useful, and they gain knowledge on how to deal with waste in their environment. In addition, with this application, the zero waste program that has been set by the government can be carried out as it should (Insani Nurchintyawati, 2022; Yasin et al., 2018). In our research this application is practical to use because there are no difficulties in using it. Our findings are relevant to other findings, namely that users feel satisfied and happy, and comfortable with the applications being developed, so they always feel like using them to solve the waste problem in today's era. In addition, we hope that the critical value in completing games or games that will be completed can be transmitted to students' critical thinking skills to deal with existing waste problems. Ease and complex design and challenging obstacles in the games we develop are one of the advantages when compared to other games. In addition to testing critical thinking skills, presenting 2D visualizations, we also present material and knowledge about waste management that are applicable, so that students can easily understand them.

4. CONCLUSION

The development of the Sorting Trash educational game uses Borg and Gall design model. The stages carried out in this development research from potential research and problems, data collection, product design, design validation, design revision, product trials, product revision, small-scale usage trials. Sorting Trash educational game was developed using Construct 3, Canva and Pixlr. The game is operated with an Android-based smart phone so that it is easily accessible to the wider community. The results of the validity test by media experts and material experts show the results of the Android-based Sorting Trash educational game are very valid so it is very feasible to use as educational media for elementary school students. The results of the usability test on educational media users, in this case elementary school teachers, show that the Sorting Trash educational game is very easy to use, the teachers will use it as educational media so it can be concluded that this Android-based Sorting Trash educational game is accepted by users.

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