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REVITALIZING SCIENCE EDUCATION: UNVEILING THE POTENTIAL OF 2D ANIMATIONS TO ENHANCE UNDERSTANDING AND ENGAGEMENT

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ABSTRACT

This research paper explores the transformative potential of 2D animations in revitalizing science education by enhancing understanding and engagement among learners. A comprehensive literature review examines previous studies on educational animations, emphasizing the cognitive impacts of visual aids on learning. The article presents an evaluation of 2D Animation for Science Secondary School Learning: Acid and Alkali. The developed application was produced to assist science students to understand the contents of the topic Acid and Alkali. An experiment was carried out to assess the effectiveness of the application as a learning tool for science students. There was a total of 32 respondents, including subject matter experts, multimedia experts and students. The findings of the current study showcased the positive impact on student engagement and learning outcomes. The results may assist in advocating for a paradigm shift in science education. The research underscores the need for innovative approaches that leverage the power of 2D animations to inspire and educate learners, thereby contributing to the ongoing revitalization of science education.

Keywords: *Animation, Science, Teaching and Learning, Multimedia, Education*

1. INTRODUCTION

Science education stands at the forefront of shaping inquisitive minds and nurturing future innovators. As we navigate an era defined by technological advancements and dynamic learning environments, it becomes imperative to reassess pedagogical strategies to invigorate science education. This research endeavors to unravel the potential of 2D animations as a transformative tool in revitalizing science education, with a primary focus on augmenting understanding and motivation among learners.

Science education plays a pivotal role in fostering critical thinking, problem-solving skills, and scientific literacy. However, traditional teaching methods often face challenges in captivating the attention of contemporary learners who are immersed in a visually rich digital landscape. To address this gap, educators are increasingly exploring multimedia tools, and 2D animations emerge as a promising avenue with their capacity to convey complex scientific concepts in an engaging and accessible manner.

The objective of this paper was to present a thorough evaluation of the usability of a visual animation work named '2D Animation for Science Form 2 Secondary School: Acid and Alkali'. This research seeks to explore the untapped potential of 2D animations, dissecting their cognitive and engagement impact on learners and evaluating their efficacy in revitalizing science education.

As we embark on this exploration, the paper will delve into the theoretical underpinnings of multimedia learning, scrutinize existing literature on educational animations, and present a comprehensive evaluation associated with the utilization of 2D animations in science education. It is envisaged the proposed work would contribute to the ongoing discourse on innovative educational practices, envisioning a future where science education is invigorated by the dynamic interplay of technology and pedagogy.

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2. LITERATURE REVIEW

2.1 Current Works

Visual aids have long been recognized as potent tools in facilitating learning. The human brain is inherently wired to process visual information more efficiently, making visual aids crucial in conveying complex concepts and enhancing retention. In the context of science education, where abstract and intricate ideas often pose challenges, the integration of visual elements becomes paramount.

Two-dimensional animations, characterized by their simplicity and accessibility, have evolved beyond mere entertainment and found a place in educational settings. There have been several studies in the literature reporting on the usage of animation, particularly in teaching and learning purpose [1-17]. In addition, there are some products which are related to the proposed visual animation for acid and alkali. For example, Science Form 2 textbook [18] and Acid and Alkali Form 2 animated video [19-20]. Recently, the researchers [21-23] contribute to the usage of animated content particularly for science education in order to enhance students' understanding and engagement. However, these products are limited for general, students and science teacher use. Besides, these applications are not interactive and the syllabus is outdated. Previous research recognizes the potential of 2D animations in science education but lacks in-depth exploration of their cognitive impacts and stakeholder perspectives. The proposed study addresses these gaps by developing and evaluating a tailored 2D animation application for teaching Acid and Alkali.

2.2 2D Animation for Science Form 2 Secondary School Learning: Acid and Alkali

Two-dimensional Animation for Science Form 2 Secondary School Learning: Acid and Alkali was developed. This research work answered the research questions which are: firstly, how do 2D animations contribute to enhancing understanding and engagement in science education and secondly, how effective is the developed 2D animation for Science Secondary School Learning: Acid and Alkali application in aiding students' understanding of the topic.

The animation consists of four modules, namely: (i) properties, (ii) use of acids and alkalis in our daily life, (iii) neutralization, and (vi) summary. This work produces a good graphical design, attractive animation and provides music background. It is a video modelling with 2D animation for secondary school students. Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5 present the screenshots of the developed 2D Animation: Acid and Alkali.

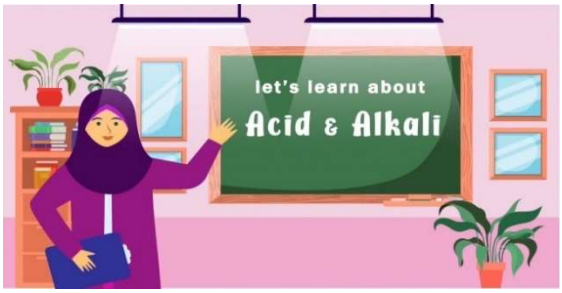

Figure 1: Screenshot of the main page

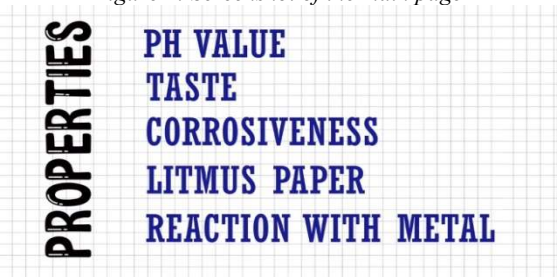

Figure 2: Screenshot of the first module page

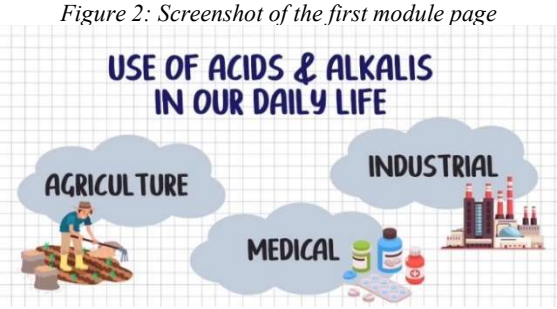

Figure 3: Screenshot of the second module page

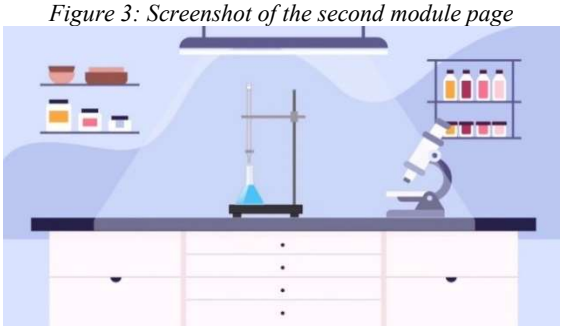
Figure 4: Screenshot of the third module page

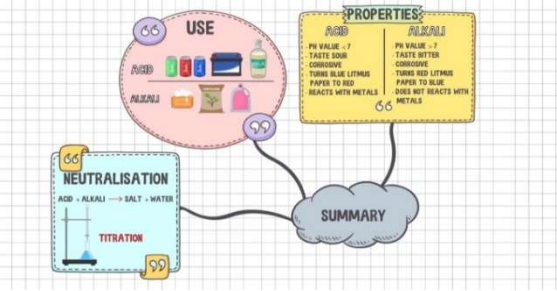

Figure 5: Screenshot of the summary module page

Table 1: Testing Respondents

	Multimedia Expert	Subject Matter Expert	Students
General Information	Person who skilled and expert in the multimedia and information technology	School teachers who teach and expert in Science subject	Form 2 of secondary school students
Description	To test the usage and effectiveness of multimedia elements in the animation	To identify the accuracy of the content and provides understanding related to the subtopics.	To identify the effectiveness of the animation for Science learning.

3. METHODOLOGY

The methodology that is used for this research work is Multimedia Production Process, as it is concerned with the incorporation of multiple media such as text, audio, video, image, and animation to increase the message's effect. This chosen methodology consists of pre-production, production and post-production stages.

The methodology section presents about the testing and outcomes. The test plan comprising of the test user, test schedule, test strategy and test implementation is elaborated in this section. The details of the respondents are presented in Table 1.

Multimedia expert is the person who skilled and expert in the multimedia and information technology field. For testing, five persons evaluated the application, focused on the usability such as the interface, interactivity, design, integration of multimedia elements and content arrangements.

Subject matter experts are individuals that have a profound comprehension of a Science topic and can help improve product or address specialized difficulty. Science teachers were selected to go through the test. They independently test the application and gave an input about the application. This testing was also being done to verify if the content in the animation was accurate and provides comprehensive coverage of the subtopics.

Secondary school student category involved Form 2 of secondary school students from SMK Bandar Putra, Kulai, Johor, Malaysia. There were 25 respondents and individually tested the product. They evaluated based on their acceptance and understanding of the product. The respondents were required to answer the questionnaire focused on the effectiveness and the content of the application.

3.1 Test Description

The total number of respondents for the testing procedure are 32 people. After receiving an explanation of the research work, each respondent conducted the testing independently. They were required to answer all the questionnaire questions. Each of the respondent was required to respond and provide comments regarding the application in their perspective.

3.2 Test Data

The test data of the user testing are explained in Table 2, while Table 3, Table 4, and Table 5 represent the data gathered from subject matter experts, multimedia experts, and students, respectively.

Table 2: Test Data for User Testing

Respondent Category	Number of Respondents
Multimedia Expert	5
Subject Matter Expert	2
Student	25

Table 3: Details of Multimedia Expert

No	Respondent	Position
1	*Respondent 1*	Head of Department of Interactive Media, FTMK, Universiti Teknikal Malaysia Melaka
2	*Respondent 2*	Lecturer, Universiti Teknikal Malaysia Melaka
3	*Respondent 3*	Lecturer, Universiti Teknikal Malaysia Melaka
4	*Respondent 4*	UI/UX Designer, Ingenious Lab Sdn Bhd
5	*Respondent 5*	Graphic Designer, Creative Stationery Sdn Bhd

Table 4: Details of Subject Matter Expert

No	Respondent	Position
1	*Respondent 1*	Science Teacher, SMK Bandar Putra, Kulai, Johor
2	*Respondent 2*	Science Teacher, SMK Bandar Putra, Kulai, Johor

Table 5: Details of Student

Institution	Total	Age	Gender
SMK Bandar Putra, Kulai, Johor	25	14 years old	Male (15) Female (10)

4. DATA ANALYSIS AND RESULTS

The current study includes diagrams and charts based on the findings of the overview and the testing measures to summarize the outcomes of the system testing.

4.1 Multimedia Experts

Five respondents consist of multimedia expert which are lecturer, UI/UX designer and graphic designer were involved in the testing. The questionnaire was given to multimedia experts. After they experienced the animation, they evaluated the animation in terms of functionality, flexibility, and the user-interface of the animation. The data collected were then analyzed and compiled into graphs. Figure 6 shows the gender of multimedia experts for the 2D animation testing. From the five respondents, three respondents are male, and another two respondents are female.

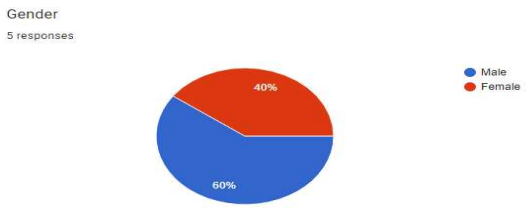

Figure 6: Gender of the multimedia experts

4.1.1 Chart of Functionality for Multimedia Experts

Figure 7 presents the data gathered from the functionality section. The functionality section evaluated the effectiveness of content delivery through multimedia functions. According to the test results, all experts agreed on the effectiveness of animation in terms of its functionality as it followed the principles of multimedia. The data indicated that all experts agreed on the animation's functionality and its practicality for student use.

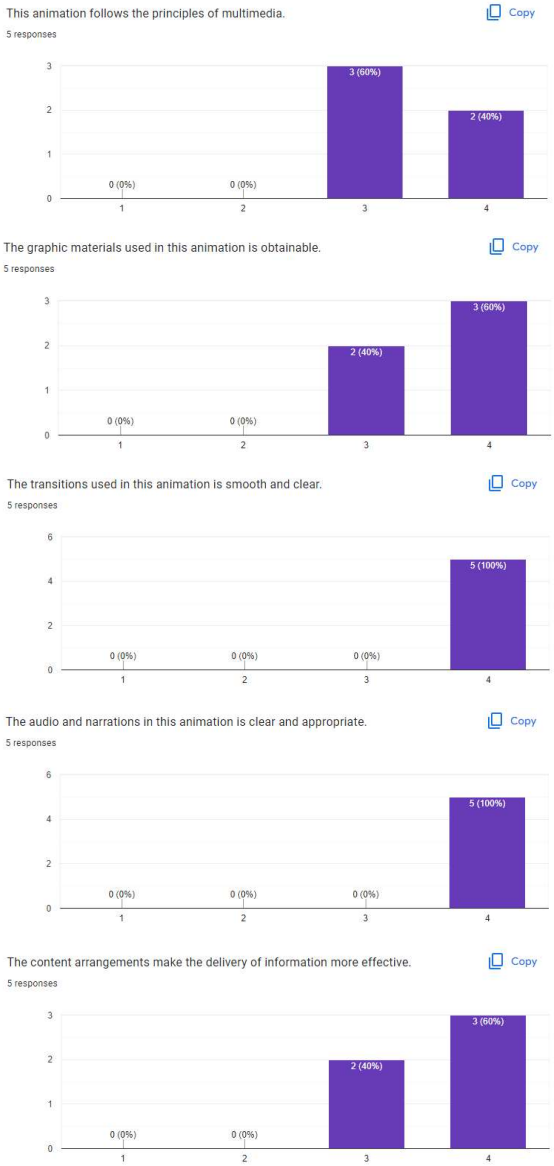

Figure 7: Results of Functionality by Multimedia Experts

4.1.2 Chart of Flexibility for Multimedia Experts

As illustrated in Figure 8, all experts agreed that the content of the animation was easy to follow despite the lack of student knowledge on the topic. Experts agreed that the audio component of the content was clear and comprehensible. Nonetheless, all the experts agreed that the utilization of animation positively impacted science students and that the content was presented in a straightforward approach,

thereby improving student learnability. Also, the experts agreed that they impressed with the animation which had the potential to enhance the learning efficacy of science students.

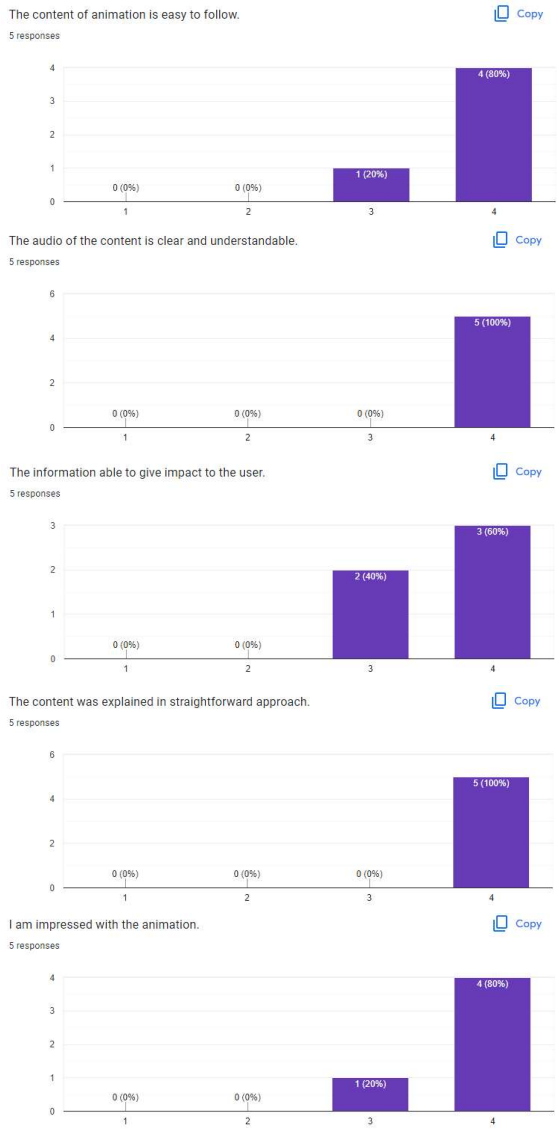

Figure 8: Results of Flexibility by Multimedia Experts

4.1.3 Chart of User Interface for Multimedia Experts

As depicted in Figure 9, the results of Question 1 revealed all experts agreed that the graphics and textual components used in this animation were appropriate and attractive for science students. It was determined by all of experts that the colours utilized in this animation were aesthetically attractive and appropriate. The colours employed in this animation made the user interface livelier and more attractive, thereby increasing the learnability of science students.

It is evident in Figure 9 that all experts agreed that the multimedia forms of the animation had successfully aided learning. The use of multimedia was important to elevate the functionality of the user interface. Nevertheless, all experts agreed that the readability of text was clear and easy to understand, also the application was user-friendly as its user interface was appropriate and attractive. This helped students to better understand the Acid and Alkali topic.

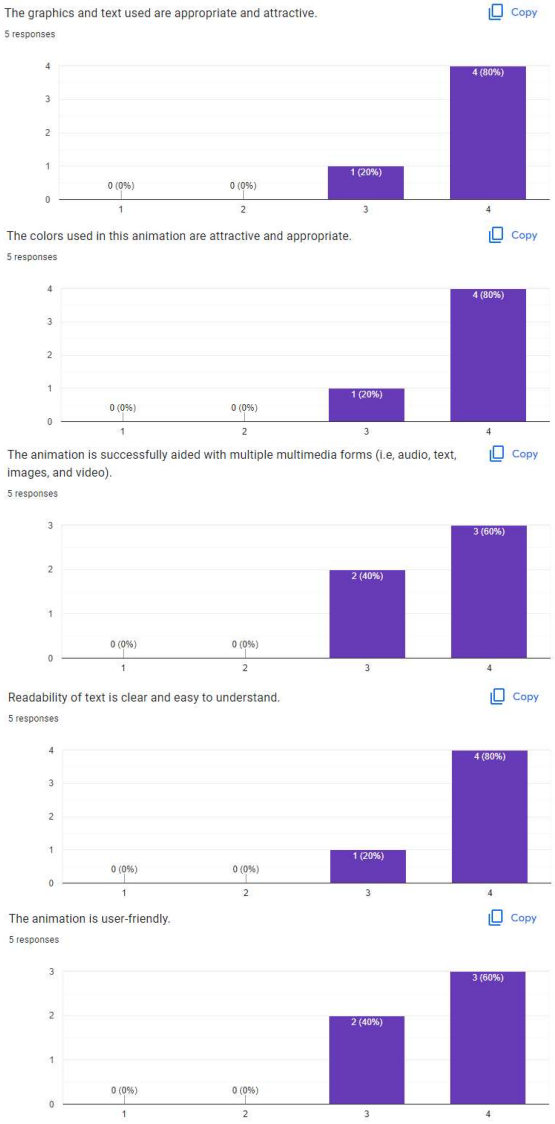

Figure 9: Results of User Interface by Multimedia Experts

The summary responses of Multimedia Expert are presented in Table 6.

Table 6: Result Summary for Multimedia Expert

Question Type	Strongly Disagree	Disagree	Agree	Strongly Agree	Total
Functionality			28%	72%	100%
Flexibility			16%	84%	100%
User-Interface			28%	72%	100%
Total			24%	76%	100%

4.2 Subject Matter Experts

Two respondents consisting of subject matter experts who were science teachers at SMK Bandar Putra, Kulai, Johor, Malaysia were involved in this testing through questionnaires. Figure 10 shows the gender of subject matter experts for the testing, both respondents are female. The data collected were then analyzed and compiled into graphs.

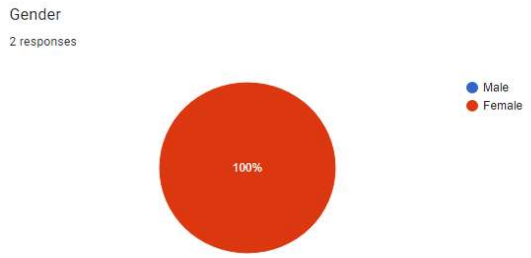

Figure 10: Gender of the Subject Matter Experts

4.2.1 Chart of Content for Subject Matter Experts

The subject matter experts evaluated the accuracy of the animation content. Based on the results obtained, subject matter experts strongly agreed on the accuracy of the content in this animation aligned with the syllabus in Acid and Alkali. Also, they agreed that the content was straightforward and easy to understand, besides the clear narrator's explanation in this animation. Overall, subject matter experts satisfied with the flow of content arrangement in this animation, as illustrated in Figure 11.

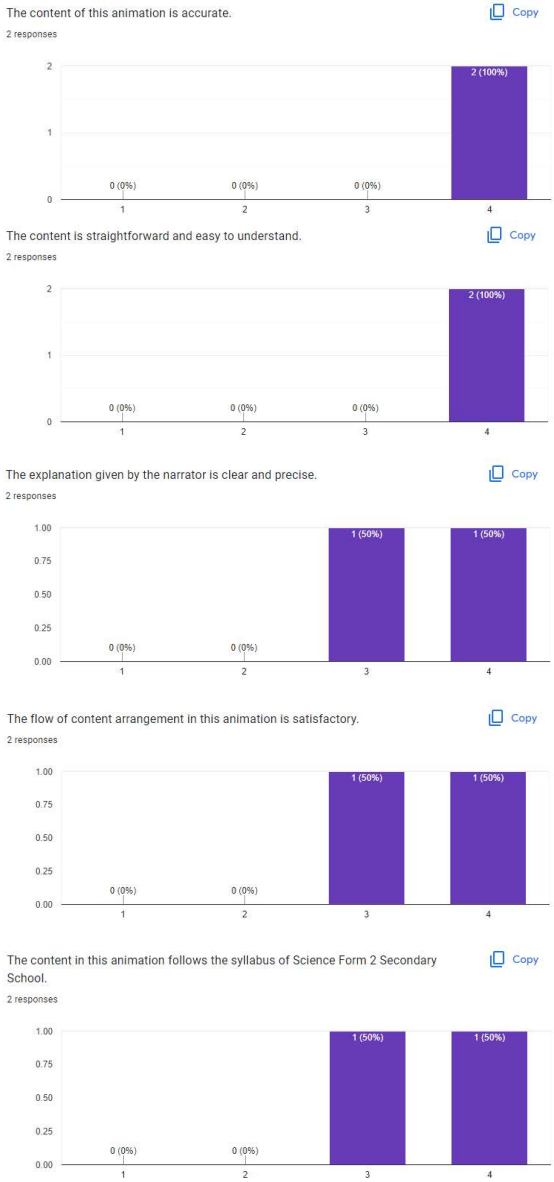

Figure 11: Result of Content by Subject Matter Experts

4.2.2 Chart of Effectiveness for Subject Matter Experts

The subject matter experts evaluated the effectiveness of the animation in helping the learning of science students and its use as teaching material. Based on the test results depicted in Figure 12, all experts were satisfied with the animation presented. They agreed that the content layout of the animation improved the delivery, thereby being useful as teaching material. Subject matter experts also believed that the use of this animation could help science students improve their learning efficiency on the topic.

Figure 12: Result of Effectiveness by Subject Matter Experts

4.2.3 Chart of Flexibility for Subject Matter Experts

In the last section, the subject matter experts evaluated the flexibility of the application as a new learning method. Figure 13 shows the findings of the flexibility on subject matter experts.

The experts agreed that the animation contents were encouraged positive user behavior. In addition, the experts agreed that the materials used in the animation were appropriate for the topic of Acid and Alkali, specifically because the materials could aid the understanding of the topic among science students. The experts believed the animation was presented in a comprehensive and effective manner, featuring good visualization and narration. The results also show that all the experts agreed on the use of this animation as their teaching material for the convenience of students in the future. This is due to the flexibility of the system being appropriate and suitable for their students.

In conclusion, all experts agree on the flexibility of the application to be implemented effectively as teaching material to aid the process of delivering the content of Acid and Alkali to science students.

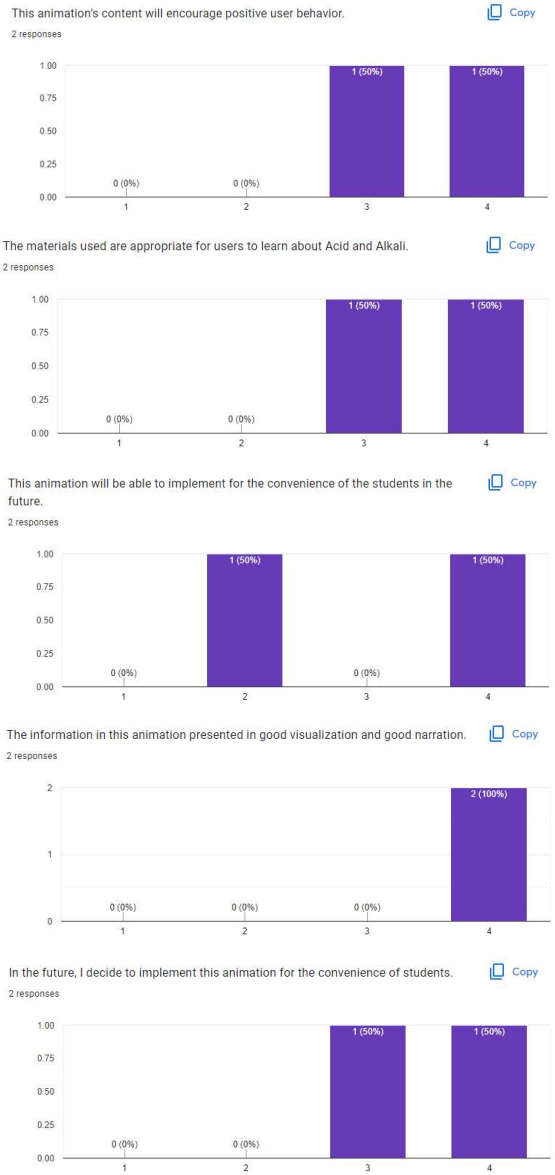

Figure 13: Result of Flexibility by Subject Matter Experts

Table 7 summarizes the findings of the study on subject matter experts.

Table 7: Result Summary for Subject Matter Expert

Question Type	Strongly Disagree	Disagree	Agree	Strongly Agree	Total
Content			30%	70%	100%
Effectiveness		10%	30%	60%	100%
Flexibility		10%	30%	60%	100%
Total		6.67%	30%	63.33%	100%

4.3 Students

The present study involved a sample of 25 Form 2 students from SMK Bandar Putra, Kulai, Johor, Malaysia. Figure 14 shows the gender distribution of the respondents. Upon completion of the animation testing phase, respondents evaluated the animation with regard to their preferred method, as determined by the questions posed in each of the three sections: efficiency, effectiveness, and user interface. The data collected were then analyzed and compiled into graphical representations.

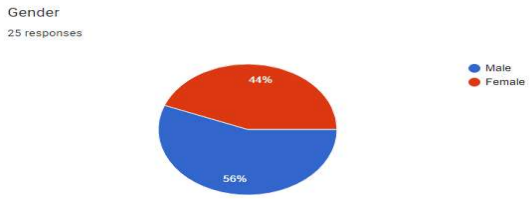

Figure 14: Gender of the Students

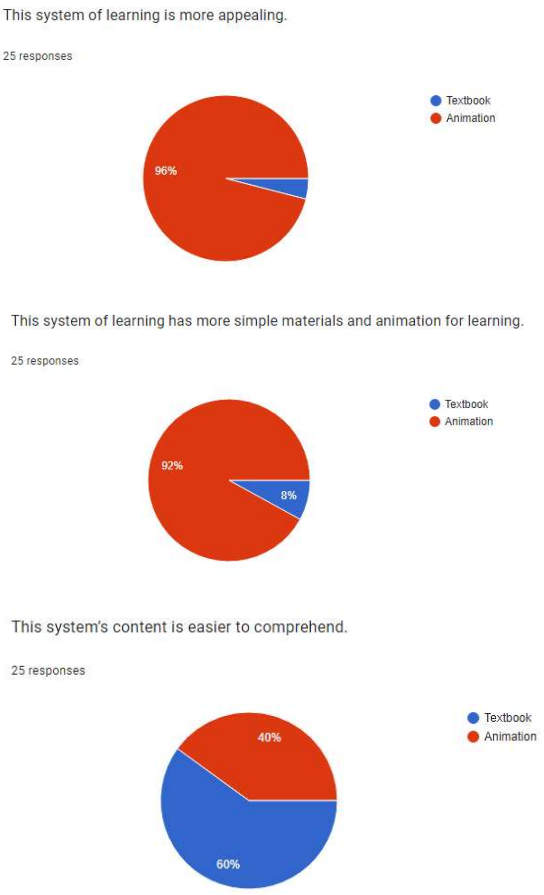

Figure 15: Result of Efficiency by Students

4.3.1 Chart of Efficiency for Students

This section presents the findings of the evaluation of the efficacy of the animation in terms of attractiveness, simplicity, and comprehension of the narrator's explanation. Student respondents were required to choose between two methods in this section.

According to the data presented in Figure 15, 96% of the respondents expressed a preference for the animation as it was a more appealing mode of learning compared to textbooks. This indicates that students were more interested in learning through interactive pedagogical approaches as opposed to textbooks. A total of 92 per cent of the student respondents decided that the animation provided a simpler explanation, whereas the remaining 8 per cent disagreed. Lastly, based on Figure 15, a total of 40 per cent of the students agreed that the content of the animation was easier to comprehend than textbooks. This indicated that students agreed that the textbooks, though more compact, provided a straightforward comprehension.

4.3.2 Chart of Effectiveness for Students

The respondents also evaluated the effectiveness of 2D Animation for Science Secondary School Learning for their learning process of Acid and Alkali. They were required to choose one of two methods: (i) animation or (ii) textbook, in terms of approach, retrieval of information, and learning impact.

Based on Figure 16, 64 per cent of the student respondents agreed that textbook employed a straightforward approach to aid their understanding of the topic Acid and Alkali, whereas the other 36 per cent agreed that same was provided by an animation. Figure 16 also demonstrated that animation assisted 76 per cent of student respondents in memorising the relevant cases of Acid and Alkali, followed by textbooks with 24 per cent of students. It is concluded that the simple explanations provided by the narrator and the colourful graphics aid in faster memorisation.

The integrated multimedia used in animation helped 80 per cent of the respondents to retrieve information on the topic of Acid and Alkali more effectively

compared to textbooks. The integrated multimedia elements were believed to help users extract information more easily.

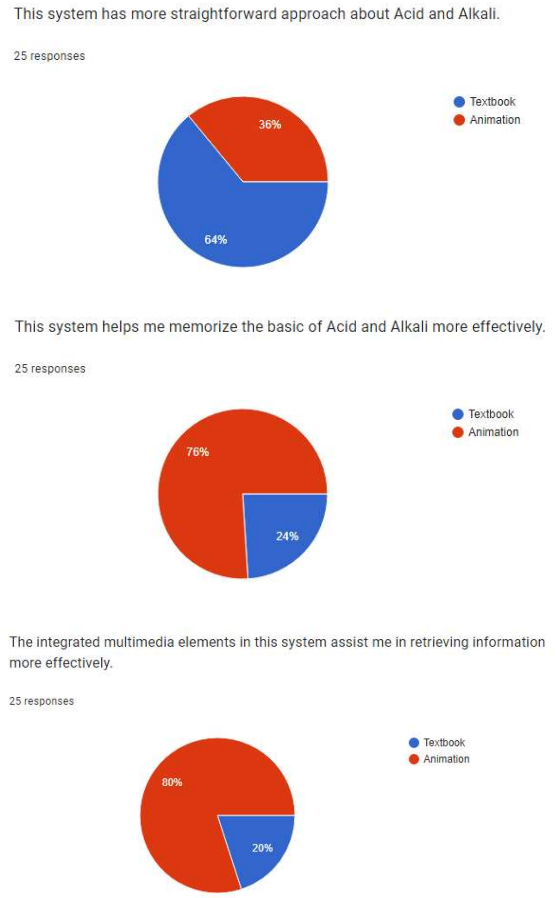

Figure 16: Result of Effectiveness by Students

4.3.3 Chart of User-Interface for Students

In the last section, student respondents evaluated the user interface of the 2D Animation for Science Secondary School Learning: Acid and Alkali. The questions in this section required the participants to choose the interface of a learning method which was more attractive, user friendly, and piqued their interest in learning the topic Acid and Alkali.

Based on Figure 17, 76 per cent of student respondents agreed that the arrangement flow of the topic Acid and Alkali in the animation provided them with a more effective way of visualizing compared to reading them on textbooks. Moreover 80 per cent of the respondents chose animation as a more visually appealing and interesting method of learning. This was attributed to the effective use of graphics, colors, and typeface. The features also resulted in the animation to be an effective tool for capturing attention.

Figure 17 shows that 72 per cent of student respondents agreed that the user interface of the 2D animation such as size and font type used helped them easier to read and comprehend in their learning, the topic Acid and Alkali better than the user interface of textbooks.

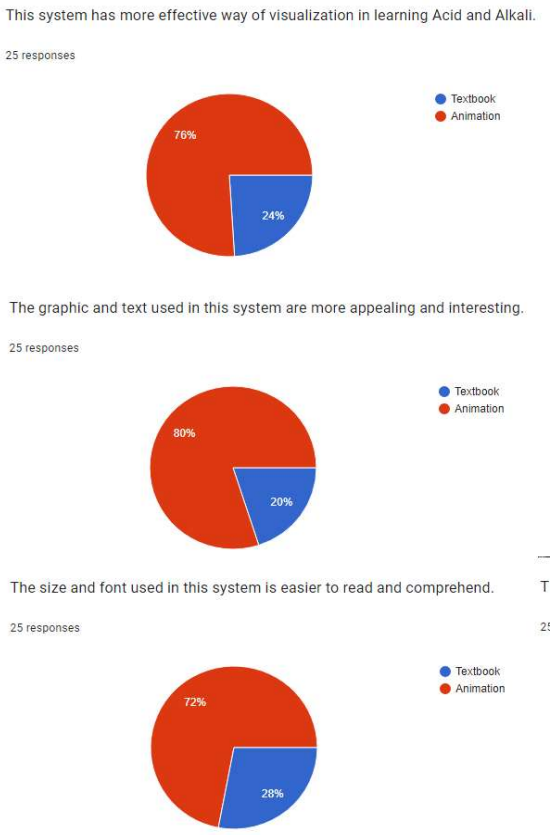

Figure 17: Result of User Interface by Students

Table 8 summarizes the testing summary for students.

Table 8: Result Summary for Students

Question Type	Animation	Textbook	Total
Efficiency	76%	24%	100%
Effectiveness	64%	36%	100%
User-Interface	76%	24%	100%
Total	72%	28%	100%

5. DISCUSSION

The evaluation of the effects of 2D animation for science secondary school learning specifically focusing on the topic of "Acid and Alkali", opens up a realm of possibilities of for

enhancing the educational experience. One of the key advantages of incorporating 2D animation into the teaching of acid and alkali concepts is the potential to make abstract and intricate scientific ideas more accessible to students. The dynamic visual representations provided by animation can effectively illustrate the properties of acid and alkalis, use of acids and alkalis in our daily life and neutralization. These visual aids have the capacity to bridge the gap between theoretical knowledge and real-world applications, fostering a more profound comprehension among students.

Multimedia elements were combined to create a successful animation in this case. Text, graphics, video effects, and animation are examples of multimedia elements used in the media integration of this animation. The plot and the character both flow effortlessly to the end. The sounds and text are both crisp and smooth. However, based on the input from the subject matter experts during the testing, there was a shortage of acid and alkali information compared to the textbook. Some part from the textbook was not delivered through the animation and may cause students not fully understand the topic. It is also recommended by the respondents to include Bahasa Melayu subtitle for students to read throughout this animation. To improve this product, the content must nearly identical to the textbook's contents. Students' learning due to the issue will suffer as a result of a lack of information. This can be fixed by including all useful details for a better user experience.

It is essential to acknowledge potential challenges and limitations associated with the use of 2D animation in science education. Access to technology, teacher training, and the availability of suitable resources are factors that may influence the successful implementation of animated content in the classroom. Additionally, the effectiveness of 2D animation may vary depending on individual student preferences and the overall teaching methodology employed. Furthermore, considerations must be given to the appropriateness of the animated content, ensuring that it aligns with the cognitive abilities and educational needs of secondary school students.

The evaluation of the effects of 2D animation for science secondary school learning on the topic of acid and alkali reveals promising opportunities for enhancing the educational experience. While acknowledging the potential advantages, it is imperative to address challenges related to implementation and consider the diverse needs of students. Future research and continued exploration of innovative teaching methods will contribute to refining the integration of 2D animation as a valuable tool in science education.

6. CONCLUSION

In conclusion, the evaluation of the effects of 2D animation for science secondary school learning, specifically focusing on the intricate concepts of "Acid and Alkali", highlights the considerable potential of this innovative educational approach. The integration of 2D animation into the science curriculum offers a dynamic and engaging method for presenting complex scientific ideas, creating a bridge between theoretical knowledge and practical applications.

The positive aspects of using 2D animation in the context of science education are evident in its ability to make abstract concepts more accessible to students. Visualizing science education through animation enhances comprehension and provides a multisensory learning experience. Thus, in turn, contributes to increased student engagement, fostering a deeper understanding of the subject matter.

However, as with any educational tool, challenges exist in the successful implementation of 2D animation. Factors such as access to technology, teacher training, and age-appropriate content must be carefully considered to maximize the benefits of this approach. Striking a balance between entertainment and educational value is essential to ensure that animated content remains a valuable tool rather than a distraction.

To finish up, the application has been effectively executed. The objective of this study was to evaluate the effectiveness of the animation namely, 2D Animation for Secondary School Science Learning: Acid and Alkali. Overall, the study provided empirical evidence supporting the effectiveness of 2D animations in science education, highlighting their potential to enhance understanding, engagement, and learning outcomes among students. We can presume that animation can be considered as useful for learning material. From the outcome and input received from the testing, a few upgrades can be made to improvise for better application.

As we move forward, it is imperative to continue exploring and refining the integration of 2D animation into science education. This involves addressing the identified challenges, conducting further research, and adapting teaching methodologies to meet the diverse needs of students.

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