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FOSTERING HIGH SCHOOL STUDENTS' LEARNING OUTCOMES ON REACTION RATE MATERIAL THROUGH USING DIFFERENTIATED LEARNING BASED INTERACTIVE MULTIMEDIA

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ABSTRACT

Interactive multimedia is one of technology integrations in learning. Implementing this multimedia with a differentiated learning approach can effectively address the diversity of students in the classroom. This study investigates the impact of interactive multimedia, which is based on differentiated learning and reaction rate material on students' learning outcomes. The method used was a quasi-experiment with post-test only control group design. The sample of this research consisted of two different classes from one of the high schools in Bengkulu City. We divided the two classes into control and experimental classes. We used interactive multimedia to teach the experimental class, while we conducted learning as usual for the control class. Both classes use the same learning model, time, and teacher to minimize bias. The data analysis used was a t-test and continued with an effect size test. The results showed a significant difference in learning outcomes between students in the control and experimental classes. The resulting effect size is 0.7405 or in the medium category. The results of this study indicate that the use of multimedia and the right approach can have a positive impact on student learning outcomes.
Keywords: *differentiated learning; multimedia; learning outcomes; quasi-experimental; reaction rate*

INTRODUCTION

Learning in the 21st century demands a learning process that utilizes advances in information technology (Nurhayati *et al.*, 2022). Information technology encompasses all tools and systems that are integrated and used to obtain, process, transmit, or present data electronically in various useful forms for users (Muthmainnah *et al.*, 2017). Information technology in the world of education moves dynamically, especially in creating media, methods, and educational materials so that the learning process can be more captivating and interactive (Hasnawati, 2019). Several studies on the technology utilization revealed a significant impact on students' motivation (Krisandini & Anwar, n.d.). Innovation in the world of education will continue to occur and develop. These developments include easier-to-find learning resources, more choices to use and utilize technology, and the increasing role of media and multimedia in learning activities. (Budiman, 2017).

Multimedia is one form of technology utilization in the learning process. Multimedia is a combination of various media formats (Jofrishal, 2014). One of the varieties of multimedia is interactive media. Interactive multimedia is a combination of various media (text, images, graphics, sound, animation, video interaction and others) that have been packaged into digital

files (computerized) (Ivers & Barron, 2002; Manurung, 2021). This media is used as a necessity for learning activities to create effective and efficient activities (Sapriyah, 2019). The use of this media has several positive impacts, such as the involvement of students in the learning process (Ang, 2020; Surbakti & Susanti, 2025). This is because interactive multimedia requires students to navigate, interact, create, and communicate with learning materials, which help them be more active and understand the material being studied. The results of literature review research also mention that the use of technology-based media has a significant impact (Ardyansyah & Rahayu, 2024). In addition, media like this can also develop students' thinking skills and achievement in subject (Febliza *et al*., 2023; Mohammed *et al*., 2023). Therefore, interactive multimedia can be an appropriate effort in presenting material so that it can improve the students' abilities.

Meeting students' learning needs can also improve their ability. This strategy is an effort to optimize learning implementation (Adha *et al*., 2016). Students have diverse characteristics and needs. Meeting the needs of diverse students can be done through differentiated learning (Rahma & Aini, 2023). Differentiated learning is learning that provides opportunities for students to learn according to their level of ability and interest, obtain the support needed, and realize their uniqueness so that the learning process can be carried out more optimally (Jannah *et al*., 2023). It is a proactive approach that incorporates inclusive strategies to create customized and accessible learning experiences that meet the educational needs of all students in the classroom (Langelaan *et al*., 2024). It is the teacher's attempt to respond to the variance of students in the classroom (Tomlinson, 2001).

In general, differentiated learning based on learning needs is divided into auditory, visual, and kinesthetic learning needs (Fitriyah & Bisri, 2023). Each learning need requires a different learning process involving visual displays, sounds, and direct work movements. This approach provides flexibility and the ability to accommodate the learning needs of students to increase their potential according to their interests and readiness to learn (Purnawanto, 2023). In addition, with this approach, excellent students can engage in more difficult learning, and novice students can increase self-confidence (Wu *et al*., 2019). In the process, differentiated learning provides opportunities for students to engage and master content (Easa & Blonder, 2024). Implementing this approach can create a learning environment that can support students' success. Previous research on the effectiveness of differentiated learning in chemistry materials obtained favorable responses from students. This phenomenon happens because through differentiated learning, students encounter a variety of chemical content delivered according to their interests and a variety of media provided so that the learning process becomes more interesting and enjoyable (Rohimat *et al*., 2023).

Learning chemistry can also benefit from the use of interactive multimedia or differentiated learning. Chemistry is a science that relates and explains the important role of its existence in nature and in society (Chang, 2010). Chemistry material is closely related to everyday life so explaining the material using interactive multimedia can be a medium that is able to explain the material with a various variation

(Irmita, 2018). One application of interactive multimedia results in interactive multimedia being considered effective because it is seen from the average learning outcomes and responses of students who use multimedia in the good category (Trixie & Ratri, 2024).

This research opens up opportunities to conduct research on the development of interactive multimedia based on differentiated learning and its application in the chemistry learning process. The variations that can be raised in interactive multimedia are in line with the variations in the needs of students, so that we can implement differentiated learning through interactive multimedia. Multimedia based on this approach has been widely developed, but for reaction rate material it is still very limited. Based on previous research, the reaction rate material in textbooks was difficult to understand (Noer, 2020), so this material was chosen as the context for the interactive multimedia development. This study aims to investigate the impact of interactive multimedia based on this approach on students' learning outcomes.

METHODS

This research is a quasi-experiment with a post-test-only control group design. This research is the implementation stage of the development of interactive multimedia on reaction rate material. The samples for this study were from two different classes at one of the high schools in Bengkulu City. These two classes consisted of a control class of 34 students and an experimental class of 35 students. Sample selection using cluster-random sampling for XI class.

The control class uses traditional learning as the habit of learning in schools used, and still involves the discussion process and laboratory activities accompanied by paper-based worksheets, while the experimental class uses differentiated learning by involving interactive multimedia in which there is a similar worksheet. This interactive multimedia becomes a tool to help the course of differentiated learning. Content differentiation was based on students' learning needs, namely audio-visual and kinesthetic. In audio-visual, students were asked to observe the existing video, while in kinesthetic, students were asked to do practical work directly. In the experimental class, students could choose to carry out learning activities based on audio-visual or kinesthetic, while the control class followed the usual teacher. To avoid bias in the intervention results, the learning model, time, and teachers in both classes are the same. The learning time used in this study was four meetings, as shown in Table 1.

Table 1. Setting Classes

Meetings	Learning Objectives	Control Class	Experiment Class
1	Proving reaction rate, reaction rate equation and order through activities	Experiment video	• Experiment video (audio visual) • Practical (kinesthetic)
2	Proving factors that affect reaction rate (concentration and surface area)	Practicum	• Experiment video (audio visual) • Practical (kinesthetic)
3	Proving factors that affect the rate of reaction	Practicum	• Experiment video (audio visual)

	(temperature and catalyst)		• Practical (kinesthetic)
4		Post-test	Post-test

The instrument used in this research is a test consisting of 20 multiple-choice questions on reaction rate material. Content validity based on expert assessment can be classified into criteria as in Table 2.

Table 2. Content Validity by Experts

Criteria	Number of Items
A	1
B	3
C	2
D	14

Based on Gregory's equation, the content validity value is 0.7 (Gregory, 2015). This test instrument is declared valid and can be used for research. This test was given at the last meeting after the learning process was completed. Process observations were not carried out because measurements were carried out at the end of the learning process in the form of a test. We then analyzed the obtained results using the t-test on R-Studio. The packages used are 'car', 'stats', and 'effsize' (Fox *et al.*, 2023; R-Core-Team, 2023; Torchiano, 2023).

The hypotheses in this study are:

Ho: There is no significant difference in learning outcomes between control and experimental class students.

Ha: There is a significant difference in learning outcomes between control and experimental class students.

This hypothesis testing uses a significance level of 0.05. There is a significant difference or Ho is rejected, when the significance value is less than 0.05. The next test is to determine the effect size using Cohen's d. Categories for can be seen in Table 3.

Table 3. Cohen's d Categories

Category	Limit
Low	0,2
Medium	0,5
High	0,8

Source: (Cohen, 1988)

RESULTS AND DISCUSSION

This research has been conducted in one of the high schools in Bengkulu City for 4 meetings with reaction rate material. The reaction rate is the last material in the high school in the first odd semester of phase F. The test instrument is given at the end of the learning process to determine the impact of the implementation of interactive multimedia based on differentiated learning. The developed multimedia can help teachers in implementing differentiated learning in the classroom, especially in differentiating students' learning needs. Figure 1 displays a screenshot of the developed multimedia



Figure 1. Screenshot of Main Menu and Learning Needs Menu

The multimedia was used for the experimental class, while the control class used paper-based tools as usual. A summary of the results for both classes can be seen in Table 4.

Tabel 4. Summary of the Results

	Control Class	Experiment Class
Minimum Value	40	44
Maximum Value	80	88
Average	63,76	71,53

Furthermore, the data were analyzed using the t-test. The results of the assumption test and t-test obtained from the use of this interactive multimedia can be seen in Table 5.

Table 5. The Results of Assumptions Test, t-test, and Cohen's d

Test Type	Class	p-value	Conclusion
Normality test	Control class	0,1883	Normally distributed
	Experimental class	0,0878	
Homogeneity test		0,3420	Homogeneous
t-test		0,0034	There is a difference in
Cohen's d		0,7405	Medium Category

This differentiated learning-based interactive multimedia emphasizes learning differentiation based on students' learning needs. Based on the implementation, students with audio and visual learning needs can choose the audio-visual menu, while students with kinesthetic needs can choose the kinesthetic menu. Audio-visual learning uses video in the data collection process. This video becomes the material for students to analyze the results. Kinesthetic learning uses lab instructions for the data collection process. In practice, kinesthetic students need to engage in hands-on activities. In the experimental class, there were 32 students with kinesthetic learning needs and 3 audio-visual students. Learning according to the learning needs of each student is expected to have an impact on their concept understanding. The activity was conducted for 3 meetings. This is what distinguishes it from the control class. In the control class, learning was done according to the learning habits in the class. The first material usually only uses experimental videos, while the second and third materials use practicum activities. The Merdeka Curriculum in the school used for research has been running for the second year, but the implementation of differentiated learning is still not optimal. This is also supported by previous research that the teacher's ability to develop differentiated learning is in the moderate category (Utari *et al*., 2025). Therefore, this multimedia can help teachers in doing so.

The implementation results are based on the results of the post-test given at the last meeting. These results were then tested for assumptions with normality and homogeneity tests. This test was carried out on both groups to ensure that the data obtained could be analyzed with parametric tests, especially the independent sample t-test. The normality test was conducted using the Shapiro-Wilk test. The normality test results showed that the p-value for the control class was 0.1883 and for the experimental class was 0.08782. Both p-values are greater than 0.05, which means that we do not reject the null hypothesis, namely that the data in both groups come from a normal distribution. In other words,

the distribution of data in these two groups does not deviate significantly from the normal distribution, which allows us to continue the analysis using the independent t-test. The variance homogeneity test was conducted to ensure that the variances in the two groups are similar, which is one of the basic assumptions that must be met to conduct an independent t-test. To test the homogeneity of variance, Levene's test was used. The results of the Levene's test showed a p-value of 0.3420, which was greater than 0.05, indicating that the variances of the two groups were homogeneous. In other words, there is no significant difference in the variance between the control class and the experimental class, which allows us to proceed with the independent t-test without concern for variance inequality.

After fulfilling the assumptions of normality and homogeneity of variance, an independent t-test was conducted to test the hypothesis that there was no significant mean difference between the two groups. The result of the independent t-test shows that the p-value is 0.0034. This p-value is smaller than the significance level of 0.05, which means we reject the null hypothesis and conclude that there is a significant difference between the mean post-test scores of the control class and the experimental class. The average post-test score for the control class was 63.76, while the average post-test score for the experimental class was 71.53. This shows that the use of differentiated learning-based learning media in the experimental class provides better results compared to the traditional approach used in the control class.

In addition to knowing if there is a significant difference, it is important to understand how large the difference is. Therefore, the effect size was calculated using Cohen's d, which gives an idea of how big the difference between the two groups is based on the standard deviation. The results of the Cohen's d calculation yielded a value of 0.7405, which falls into the medium-size effect category. This shows that although there is a significant difference between the two groups, the difference is not very large, but it is meaningful enough to show that the use of interactive multimedia in learning has a real impact. In addition, these results provide further confidence that the differences found between the two groups are not coincidental but rather reflect substantial differences, albeit on a medium scale. From these results, it can be concluded that this interactive multimedia has a significant positive impact on student learning outcomes when compared to the traditional approach. The use of interactive multimedia in learning has been shown to improve student understanding, which is reflected in the higher results in the experimental class post-test. In addition, the medium effect size indicates that although the difference is significant, there is still room to improve the effectiveness of using interactive multimedia in learning in the future. This conclusion is consistent with previous research that the development and use of interactive media can improve student performance (Agustin *et al*., 2025; Nisa *et al*., 2023; Wardani *et al*., 2023)

One recommended approach for the Merdeka Curriculum learning process is differentiated learning. This approach is an application of the principle of the 'teaching at the right level' approach, which involves adapting teaching to the needs of students and the diversity of their interests and readiness, and needs to be developed in the implementation of the Merdeka Curriculum

(Samsudi *et al*., 2024). Differentiation embraces heterogeneity in each class so that the treatment of students from one another can be differentiated according to their needs for learning in the classroom. Differentiated learning emphasizes that when students' learning needs are met, they will more easily understand the learning material presented. We divide this approach into process, product, and content components. This research focuses on the content and process components.

The heterogeneity of learning needs in the experimental class was not too diverse because there were only three people who had audio-visual learning interests and needs. Each student has unique learning needs when it comes to using learning media (Sugiarto *et al*., 2022). Students with audio-visual learning needs are not interested in doing hands-on practicums. They prefer to observe and listen to videos provided in the learning media. This is in accordance with the aim of this approach that students can adjust individual profiles in the learning process (Easa & Blonder, 2024). In the long run, this differentiated learning can create a learning environment that can improve students' academic performance (Villamor & Lapinid, 2022).

Differentiated learning-based interactive multimedia is a learning tool that uses technology to present learning information. Interactive multimedia is a tool that can be used to assist students in learning. It contains diverse content (e.g., images, videos, texts, and animations) and is interactive. The content can help students in developing their thinking process. In addition, this diverse content can address diverse students (Salleh *et al*., 2022). It is outlined in this study that diverse students need diverse content. Students with kinesthetic learning needs require hands-on practice, while students with audio-visual learning needs require sound and visual media. Both have the same function: to make students understand the concepts taught. In this interactive multimedia, kinesthetic students can do practicums using practical procedures, while audio-visual students can observe experimental videos. Through the use of this multimedia, students are proven to be able to learn in a more engaging and understandable way. It also provides a more engaging and interactive learning experience for students.

The results of this study provide evidence to support the use of technology, particularly interactive multimedia, as an effective tool in improving student learning outcomes. Multimedia-assisted learning can be adapted and applied in various educational contexts to encourage more creative and innovative teaching methods. The use of multimedia as part of a differentiated learning strategy can be a very useful alternative in creating a more interesting and enjoyable learning experience for students, which in turn can improve their learning motivation and academic outcomes. The use of multimedia in this educational context can also contribute to 21st century competencies, especially digital literacy (Sorokolit *et al*., 2024).

CONCLUSION

Based on the results and discussion, it can be concluded that the use of interactive multimedia based on differentiated learning can improve students' learning outcomes, especially in reaction rate material based on the t-test results. Meanwhile, the effect size given by this treatment is 0.7405 or in the medium category. This multimedia can be used as a tool by chemistry teachers in

implementing differentiated learning. It can also facilitate joyful learning, a component of deep learning, due to the interactivity it offers.

Although interactive multimedia-assisted learning is proven to be more effective, the results of this study also suggest that more research be conducted to further explore the factors that can increase the effectiveness of multimedia in education. Several factors that may affect learning outcomes, such as the type of multimedia used, duration of use, and interaction between students and materials, need to be considered for future research. Further research can also include experiments with a larger sample size to strengthen the results obtained. Furthermore, it could explore the development and implementation of similar interactive multimedia, but with different materials. Integration of 3D shapes, augmented reality, and virtual reality could also be implemented to make it more engaging for students. The lack of process observation is a weakness of this study, so future research should include observations during the learning process using this multimedia.

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