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Development of CHEMISTER as Chemistry Education Media with Socioscientific Issues Approach Integrated with Augmented Reality to Support Education for Sustainable Development

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Abstract: Learning in Indonesia currently still focuses on theoretical knowledge, so that the implementation of Education for Sustainable Development (ESD) is not optimal. Chemistry is a suitable subject to teach sustainable principles in accordance with ESD principles, especially on the topic of reaction rate. However, there are problems for students in understanding the reaction rate, as evidenced by students' concept understanding of this material being only 26%, and only 33.3% of students managed to get a score above the KKM. These problems can be caused by the limited learning media that facilitate students in learning the reaction rate. Therefore, this research aims to develop educational kit-based learning media on reaction rate material with the Socioscientific Issues (SSI) approach integrated with augmented reality technology as an effort to support ESD. This research method uses Research and Development (RnD) level 1 with five stages, namely potential and problems, literature study and information gathering, product design, design validation, and tested design. The results showed that the learning media presented in the form of educational kits with the SSI approach equipped with mobile applications, game cards, flashcards, and practicum kits with the concept of green chemistry have been produced. This product is a suitable educational media in an effort to improve the quality of education through the implementation of ESD.

Keywords: reaction rate, socioscientific issues, augmented reality, ESD

INTRODUCTION

Education becomes an essential component in providing understanding, perspective, and sustainable living skills that are in line with the principles of Education for Sustainable Development (ESD) (Vioreza et al., 2023). The concept of ESD in Indonesia is reinforced in Permendiknas No. 40 of 2006 on Policy Materials, Programs, and Activities Related to Tasks and Functions in Establishing ESD Implementation (Utami and Vioreza, 2021). This is demonstrated by the elements that should be achieved in ESD-based education, such as critical thinking and problem-solving skills, in Indonesian students who are still low.

In connection with the above, chemistry, especially on the subject of reaction speed, is a suitable subject for teaching sustainable principles (Jensen et al., 2021). The velocity of reactions is also an important material studied by students as a prerequisite to the study of more complex chemical materials, such as chemical equilibrium and acid-base equilibrium (Jusniar et al., 2020). On the other hand, studying the speed of reactions involves mathematical equations, algorithmic abilities, and requires three levels of representation, namely symbolic, macroscopic, and submicroskopic (Jusniar et al., 2020). This results in the concepts on the speed of the reaction matter being largely abstract, making it difficult for students to understand. This is in line with the problem related to the student's understanding of the concept of reaction material that averages only 26% (Marthafera et al., 2018). In addition, only 33.3% of students managed to score above KKM on reaction speed material (Nababan and Silaban, 2021). The problem can be caused by the limited learning media that facilitates students in learning the speed of reaction (Azizah et al., 2022).

The above problem suggests that chemistry learning activities are needed through learning media that can solve students' difficulties in learning reaction speed. Socioscientific Issues (SSI) approach becomes an interesting approach when applied in learning media. Through this approach, learning chemistry is more relevant to student life (Siska et al., 2020). The SSI approach not only emphasizes student understanding of concepts, but also teaches the implementation of scientific knowledge to solve socio-scientific problems in everyday life (Afrilya et al., 2019). In connection with this, environmental issues have become a very relevant SSI topic in reaction speeds (Jensen et al., 2021). Students can explore reaction-speed material and associate it with environmental damage prevention, such as the use of fossil fuels that lead to climate change, acid rainfall, to global warming.

According to Cheng et al., (2020), games have become an effective medium for educating about the environment. In chemistry learning, the role-playing game method can be used in the learning process as it can improve student learning understanding and motivation (Hasanah, 2020). In addition, the SSI approach implemented in gaming media becomes an effective medium for raising environmental awareness through issues raised, enhancing critical thinking through decision-making in playing games, and enhancing communication skills (Tsai et al., 2019). Technological involvement, such as the use of augmented reality, can also help students to understand abstract chemistry concepts, thereby increasing learning motivation (Chusna et al., 2021).

There are several reactive learning media that have been developed today. However, the learning media is not optimal in solving the problems that students face when learning reactive material, such as the difficulty of understanding abstract concepts due to the limitations of learning media that are easily accessible and understood by students. Therefore, in this study, the author developed a chemistry learning medium on reaction-speed material in the form of an educational kit with a socioscientific issues approach integrated with a mobile application with augmented reality features. This product is a suitable educational medium in an effort to improve the quality of education in accordance with the goals of the government in the fourth item of the SDGs, namely Education for Sustainable Development.

METHOD

This research method uses Research and Development (R&D) level 1 with five stages, namely potential and problems, literature study and information gathering, product design, design validation, and tested design (Sugiyono, 2017). The following is a flowchart of the stages of this research. This research was conducted in April-June 2024 at the State University of Malang. The data collection technique at the potential and problem stages uses simple random sampling with a questionnaire instrument distributed to high schools in Malang City. In this research and development, it is still carried out until the third stage, namely product design. The design validation stage and tested design have not been carried out by researchers due to limited time and money.

RESULTS AND DISCUSSION

Phase 1: Potential and Problems

At this stage, the search for potential and problems is carried out to explore and find a problem related to chemistry learning in schools. The step taken is to distribute questionnaires to students majoring in high school science in Malang City, which contain several question criteria as follows: (a) analysis of the difficulty of chemistry material, (b) learning methods that students like, (c) student availability in learning chemistry based on environmental damage issues, and (d) types of chemistry learning media that students like. Based on the distribution of the questionnaire, it was found that 57.8% of students considered the reaction rate material to be difficult.

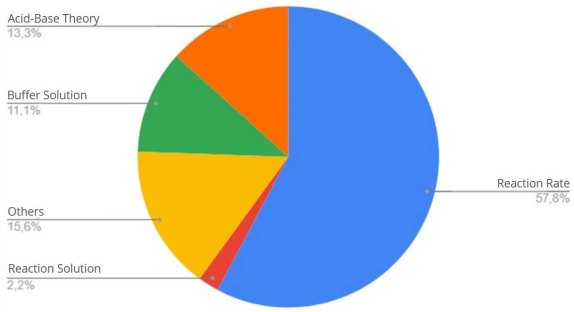


Figure 1. Survey Result of Chemistry Materials Considered Difficult

This becomes a fairly complex problem, especially for teachers in teaching chemistry so that it can be easily understood by students. The group discussion method is the method most favored by students, with a percentage of 60%, while as many as 33.3% of students prefer practicum-based learning. As many as 61.4% of students want chemistry learning based on environmental damage issues and agree that environmental damage can be explained and understood easily by using chemistry learning.

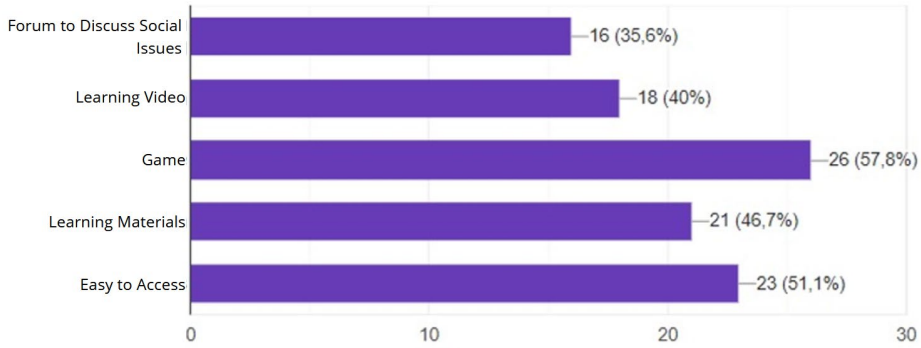


Figure 2. Survey Results of Students' Favorite Learning Media

Based on this data, it can be said that students want chemistry learning that is applicable to environmental issues in everyday life. As many as 57.8% of students prefer game-based learning media, and 51.1% of students want learning media that is easily accessible. According to the survey results, it can be identified that students tend to have difficulty understanding chemistry subjects, especially on reaction rate, because they do not know the implementation of chemistry in everyday life. Therefore, a solution is needed in the form of developing chemistry learning media that has added value, is favored by students, and is in accordance with student needs.

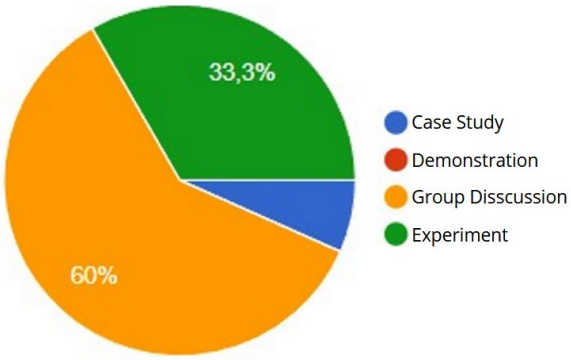


Figure 3. Survey Results of Students' Preferred Learning Methods

In this case, students need learning media that can facilitate their understanding in learning reaction rate material, game-based, or group practicum so that learning is not boring. Not only that, but students also want chemistry learning that can be directly applied in everyday life. Based on the

problems that have been explored, it can be said that the development of innovative educational media in chemistry learning has great potential in overcoming students' difficulties in learning reaction rate material.

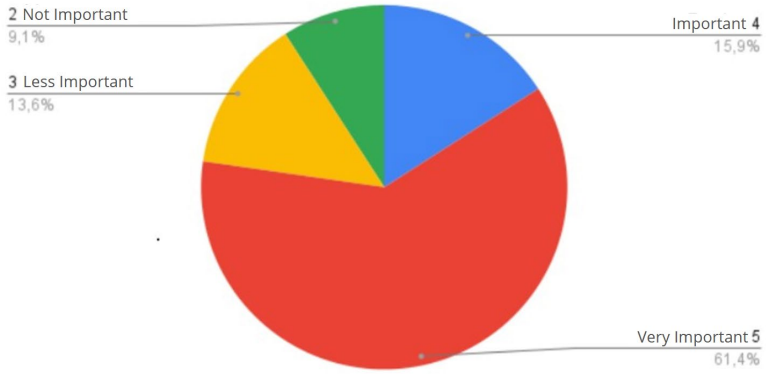


Figure 4. Survey Results Related to the Importance of Learning Chemistry Based on Socioscientific Issues

Phase 2: Literature Study and Information Gathering

The second stage was carried out by studying literature and collecting information as a theoretical basis that strengthens product development. Based on the results of the problem analysis and potential opportunities, researchers developed a chemistry learning educational media kit on reaction rate material with a socioscientific issues approach equipped with mobile applications and learning concepts with gamification. The use of gamification concepts with role playing game-based game card facilities is based on the results of the author's survey, where the majority of students like game-based learning. This is supported by the results of research by Cheng et al. (2020), who said that games have the potential to be an effective medium in educating about the environment. According to Hasanah (2020), in learning chemistry, the role playing game method can be used in the learning process because it can increase students' understanding and motivation to learn. This statement is in line with the results of the author's survey, which shows that most students want to learn chemistry related to environmental problems and issues in everyday life. This is because the majority of students do not know the actual use of chemistry for the surrounding environment.

Therefore, the educational media that the author developed using the SSI approach aims to help students apply chemistry, especially in reaction rate, which is considered difficult, to the surrounding environment directly. This is in line with the research of Tsai et al. (2019) which states that the SSI approach implemented in game media is an effective medium for increasing environmental awareness through the issues raised, improving critical thinking skills through decision-making in playing games, and improving communication skills. Not only that, the author also develops mobile applications to facilitate access to learning chemistry in accordance with the survey results, which show that students want learning media that is easily accessible anytime and anywhere. The use of technology is also developed by the author with augmented reality (AR) technology with the hope of being able to help students in representing abstract concepts in reaction rate material, so that reaction rate material that was originally considered difficult can be understood easily. This is supported by the research of Chusna et al. (2021) regarding the involvement of technology, such as the use of augmented reality, which can also help students in understanding abstract chemical concepts so as to increase learning motivation.

Phase 3: Product Design

Based on the results found in the potential and problem stages, as well as literature studies and information gathering, a more in-depth analysis was carried out related to learning media in accordance with the problems in the field. The learning media developed was named CHEMISTER. CHEMISTER is a chemistry learning media on reaction rate material that carries the Socioscientific Issues (SSI) approach. CHEMISTER is packaged in the form of an educational kit equipped with LKPD, Teaching Modules, Handouts, Game Cards, Flashchem, practicum kits, and mobile applications that come with Augmented Reality technology.

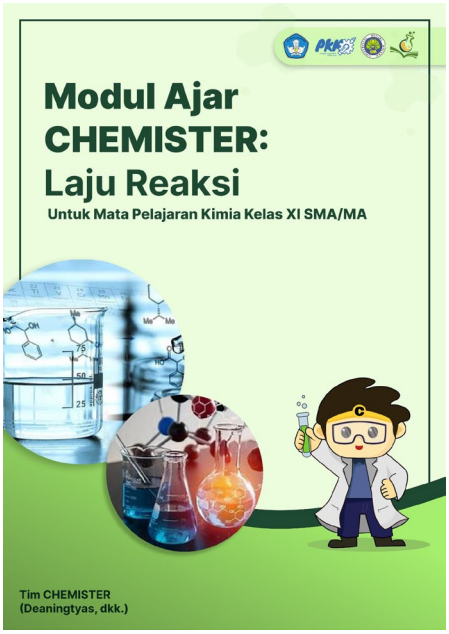
Figure 5. Learning Media CHEMISTER

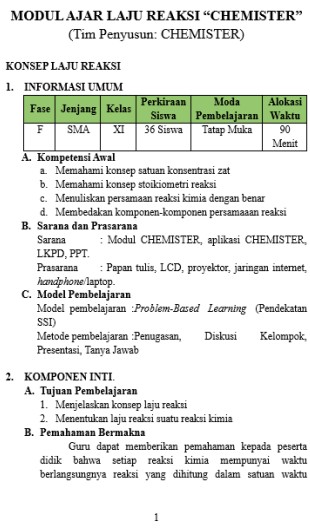
Learning Media with Socioscientific Issues Approach

CHEMISTER raises the socioscientific issues (SSI) approach, which is implemented on reaction rate material. SSI is a problem related to social issues that occur in society, which include concepts and technology and their relationship with science. The use of this approach aims to facilitate students' understanding of abstract chemistry concepts through the context of socio-scientific issues in society. Through this approach, chemistry, especially reaction rate material, becomes closer to everyday life and is useful in solving social-science problems. The SSI issues raised focus on preventing environmental damage based on the concept of reaction rate, such as the issue of fossil fuel use that results in climate change, acid rain, and global warming. For example, in the fuel combustion reaction in a vehicle engine, a greenhouse gas formation reaction occurs in the form of NO2 gas. In the context of reaction rate, the concentration of reactants is one of the factors that affect the rate of NO2 gas formation. Through the principles of slowing down the reaction rate, students can contribute to reducing the environmental impact of fossil fuel combustion by reducing the rate of NO2 gas formation by reducing the intensity of motor vehicle use.

Teaching Modules and Teaching Materials

Teaching modules are devices in the form of documents that contain objectives, learning media, learning syntax, and assessments needed in one topic arranged based on the Flow of Learning Objectives. Teaching modules in CHEMISTER are made to facilitate teachers in determining a set of learning activities on reaction rate material. There are core components in the teaching module, such as Learning Objectives, Meaningful Understanding, Triggering Questions, Learning Activities, and Reflection.





MODUL AJAR LAJU REAKSI "CHEMISTER"
(Tim Penyusun: CHEMISTER)

KONSEP LAJU REAKSI

1. INFORMASI UMUM

Fase	Jenjang	Kelas	Perkiraan Siswa	Moda Pembelajaran	Alokasi Waktu
F	SMA	XI	36 Siswa	Tatap Muka	90 Menit

A. Kompetensi Awal
a. Memahami konsep satuan konsentrasi zat
b. Memahami konsep stoikiometri reaksi
c. Menuliskan persamaan reaksi kimia dengan benar
d. Membedakan komponen-komponen persamaaan reaksi

B. Sarana dan Prasarana
Sarana : Modul CHEMISTER, aplikasi CHEMISTER, LKPD, PPT.
Prasarana : Papan tulis, LCD, proyektor, jaringan internet, *handphone*/laptop.

C. Model Pembelajaran
Model pembelajaran :*Problem-Based Learning* (Pendekatan SSI)
Metode pembelajaran :Penugasan, Diskusi Kelompok, Presentasi, Tanya Jawab

2. KOMPONEN INTI.

A. Tujuan Pembelajaran
1. Menjelaskan konsep laju reaksi
2. Menentukan laju reaksi suatu reaksi kimia

B. Pemahaman Bermakna
Guru dapat memberikan pemahaman kepada peserta didik bahwa setiap reaksi kimia mempunyai waktu berlangsungnya reaksi yang dihitung dalam satuan waktu

1

Figure 6. Display of CHEMISTER Teaching Module

In addition, there are cognitive, skill, and affective assessment instruments that make it easier for teachers in the process of assessing students. To support learning activities, there are teaching materials in the form of books as additional reading materials that can increase students' knowledge related to reaction rate.

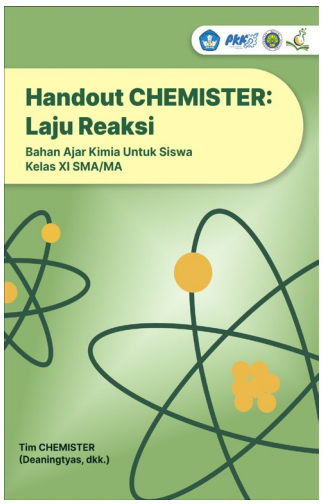


Figure 7. Display of CHEMISTER Teaching Material (handout)

Learner Worksheet

Learner Worksheets (LKPD) are printed teaching materials that contain material, summaries, and instructions for implementing learning tasks that must be done by students, which refer to the basic competencies that students must achieve. LKPD in the CHEMISTER educational kit uses the SSI approach with the Problem-Based Learning (PBL) learning model. PBL is a learning model based on problems in everyday life as a context for students to learn about critical thinking and problem solving skills so as to obtain essential knowledge and concepts from the subject matter (Nafiah et al., 2014). The syntax used follows the flow of the PBL learning model, which consists of: 1) Orienting Learners to the Problem; 2) Organizing Learning Activities; 3) Gathering Information; 4) Group Investigation; 5) Developing and Presenting Work; and 6) Analyzing and Evaluating the Problem Solving Process. In the LKPD CHEMISTER Reaction Rate, there are

three sub-materials consisting of the Concept of Reaction Rate, Law of Reaction Rate, and Factors Affecting Reaction Rate.

Figure 8. Display of CHEMISTER Learner Worksheet

Practicum Kit with Green Chemistry Concept

The practicum kit in CHEMISTER uses the concept of green chemistry, which is the application of chemistry in reducing or eliminating the use of harmful substances during digestion. The materials used in this lab kit are environmentally friendly, such as the use of vinegar, eggshells, and baking soda, so that the waste produced does not have the potential to damage the environment. The equipment in this lab kit includes spatulas, measuring cups, beakers, and dropper pipettes. The practicum kit in CHEMISTER is used when entering the material on factors that affect the reaction rate. Students can investigate how these factors can accelerate or slow down the reaction rate through activities with this lab kit.

Figure 9. CHEMISTER's Practicum Kit

Mobile Application

This research produces a product in the form of a mobile application as one component of the CHEMISTER product that can be accessed using the internet via a smartphone. This mobile application is equipped with various features as follows:

Learning Outcomes (Capaian Pembelajaran). This feature contains learning outcomes and learning goal to be achieved in learning chemistry on reaction rate material in accordance with the Merdeka Curriculum.

Matter (Materi). This mobile application is equipped with a feature that contains material to assist students in exploring reaction rate material and adding material reference materials other than the textbooks provided by the school.

Games. This feature is in the form of an interesting game related to the reaction rate, which aims to facilitate students in understanding the concept of reaction rate and foster student learning motivation so that learning becomes more interesting.

Forum Disscussion. This feature is a place for student discussions related to socioscientific issues related to reaction rates. This discussion group feature can still be used for discussion even though the learning activity is over, because it can be accessed anytime and anywhere.

CHEMISTER-AI. This feature facilitates students to discuss directly with AI bots so that students can get broader answers about reaction rates.

Scan AR. This feature is used to scan AR cards that will bring up 3D images of abstract concepts in reaction rate material. This feature helps make it easier for students to visualize these abstract concepts.

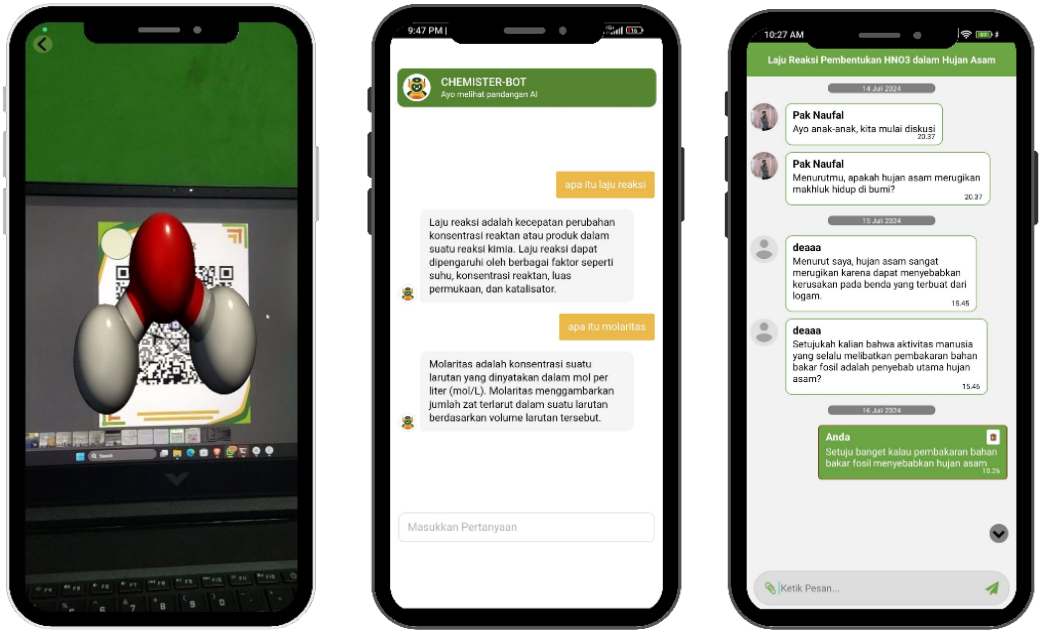


Figure 10. Display of CHEMISTER Mobile Aplication

Game Card

The integration of SSI approach and gamification concept in CHEMISTER can improve students' critical thinking, problem solving, and communication skills through fun learning. This card game uses a type of role-playing game, where students will play a role to complete certain missions and convey their point of view according to the role they get related to the socioscientific issues raised. This game media can train students' ability to communicate, express opinions, and think critically so that it is expected that there will be an increase in problem-solving skills.

Figure 11. *Game Card* CHEMISTER *Flashchem*

One of the CHEMISTER components is flashchem which is a flash card that contains a summary of important concepts or formulas in reaction rate material that is designed as interesting as possible. Flash card media can make it easier for students to remember important concepts in reaction rate material.

Figure 12. Display of Flashchem

CONCLUSIONS

Based on the results of the research conducted, the survey results show that 1) 57.8% of students have difficulty in understanding reaction rate material, 2) 60% of students like group discussion learning methods and 33% of students like practicum-based learning, 3) 61.4% of students want chemistry learning based on environmental damage issues, and 4) 57.8% of students like game-based learning media and 51.1% of students want learning media that is easily accessible. Therefore, CHEMISTER comes as a learning media in the form of educational kits with the Socioscientific Issues approach equipped with mobile applications, game cards, flashcards, and practicum kits with the concept of green chemistry. This product is a suitable learning media in an effort to improve the quality of education according to the government's goals in the fourth point of SDGs, namely Education for Sustainable Development in order to realize quality education.

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