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Development of Augmented Reality-Assisted Practical Guide Media for Thermochemistry Practicum and Its Effectiveness in Improving Students' Learning Outcomes

Giska Amirah [1], Ira Mahartika[2], Suyanta[2]

[1,3] Departement of Chemical Education, Faculty of Mathematics dan Natural Science Universitas Negeri Yogyakarta, Jl. Colombo No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta, Indonesia.
[2] Department of Chemical Education, Faculty of Faculty of Teacher Training and Education Universitas Islam Negeri Sultan Syarif Kasim Riau, Jl. HR. Soebrantas No.Km. 15, RW.15, Simpang Baru, Kota Pekanbaru, Riau, Indonesia.

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Corresponding Author:
Giska Amirah
giskamirah2@gmail.com

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Abstract: The governments's goal to produce graduates able to compete in all technology era must be realized by using media with technological assistance in the learning process. Chemistry learning focuses on providing direct experience which can be in the form of practical work activities. The limitations of laboratory facilities, tools, and practical work materials hinder the implementation of practical work activities, but this can be minimized, one of which is with Augmented Reality assistance. This research aimed at producing Augmented Reality assisted practicum guide media in Thermochemistry practice that was valid and practical based on the result of validity test by material, media and language experts and practical test by chemistry teacher and students. Research and Development method was used in this research with ADDIE research design, and the steps were (1) Analyze, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. Material experts validation result have a percentage 80% with valid category, media experts have a percentage 79,6% with valid category and linguist have a percentage 100% with very valid category. The percentage of practicality test by Chemistry subject teachers was 82% with very practical category, and the percentage of student response practicality test was 86% with very practical category. Based on the test result of validity and practicality it could be concluded that Augmented Reality assisted practicum guide media in thermochemistry practice was very appropriate and practical to be used as a learning on thermochemistry. This practicum guide has also been tested for its effectiveness on students' learning outcomes using a Single group pretest-posttest design. The results of the non-parametric test with the Mann-Whitney test obtained a calculated Uhitung of -132. This value is smaller than its Utabel of 123, which means that H0 is rejected and Ha is accepted. It can be concluded that there is a difference in students' learning outcomes in learning chemistry between classes that apply Augmented Reality-assisted practicum guide media or not in thermochemistry practicums.

Keywords: Augmented Reality; Practicum Guide; Thermochemistry.

Introduction

Education plays a significant part in lives of individuals, helping them improve their quality by sharpening their mindset and potential. The purpose and function of education is contained in Law Number 20 of 2003 article 3, concerning the national education system, which reads: "National education functions to develop abilities and shape the character and civilization of a dignified nation in order to educate the nation's life, and aims to develop the potential of students to become human beings who are faithful and devoted to God

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Almighty, noble, healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens" (Rarastika, 2022).

Technology is progressively advancing and influencing many facets of life, including social, political, economic, and educational domains that now rely on technology. Technology is currently rapidly evolving and influencing all parts of life, from social, political, and economic to education, which is entirely reliant on technology. This indicates that our times have entered a new period known as the Fourth Industrial Revolution (4.0), which is defined by the growth of artificial intelligence, genetic engineering, nanotechnology, and other innovations in technology. These sophisticated technologies should be employed in learning activities to refresh teachers and students, particularly those who require refreshment in terms of using learning media.

Learning activities should focus on providing direct experience to improve competences, particularly in the science learning process, which includes chemistry. Thermochemistry is one of the most challenging chemical materials since it demands strong analytical abilities in theory and calculation, necessitating direct practice to encourage students to analyze the material studied (Rahma et al., 2019)). According to article 1 paragraph 20 of the National Education System Law No. 20 of 2003, learning is more than just a connection between students and educators; it is also the process of interacting students with their learning environment. According to Minister of Education and Culture Regulation No. 81A of 2013, there are five learning processes: observing, questioning, gathering information, associating, and communicating results, all of which can be carried out through practicum activities.

Practicums can run effectively if it is accompanied with supportive resources such as practicum handbooks. This "sacred book"" plays an important role in the science learning process (Salirawati et al., n.d.). The practicum guide is a guideline that provides processes for practicum preparation, implementation, data analysis, and reporting (Minister of National Education, 2011). In addition, the practicum handbook includes laboratory safety recommendations and symbols. The purpose of the practicum guide is to make practicum activities take place in a directed and sustainable manner (Syamsu, 2017).

The implementation of chemistry practicum at the high school level cannot necessarily be implemented in an instant. Chemistry practicums in high schools cannot always be implemented immediately. There must be supporting components, both in terms of facilities and human resources. Study on the relationship between practicum implementation and student chemistry learning outcomes discovered several issues that contribute to the difficulty of carrying out practicum activities, including the fact that many schools still lack well-equipped laboratories (Anggraini et al., 2022). In addition, the capacity and motivation of teachers to conduct practicums, as well as the availability of laboratory facilities and budget to offer tools and chemicals for use during practicum. Risks associated with job safety during practicum form a long list of challenges to completing chemical practicum.

Technology and education are two aspects that complement one another in this age of technological advancement. Technology can help teachers deliver materials for learning. Technology is not a new phenomenon in the field of education, as evidenced by its extensive application in the learning process. Augmented reality technology has been employed in the educational process and has produced good outcomes. Clarinda et al's (2022) research on the usage of virtual laboratories, in which students use PhET to assist the implementation of virtual practicum, found that virtual practicum done in virtual laboratories can increase student learning outcomes. Research on the effect of Augmented Reality-based learning media conducted by Kamaruddin & Thahir (2021) shows that the media is able to improve student learning outcomes. Another study conducted by Sumardani et al (2020) on the Augmented Reality laboratory in physics learning also indicates an increase in post-test results after learning activities with the Augmented Reality laboratory.

When compared to real-life practicum, using Augmented Reality to support the implementation of practicum activities has several advantages, including the ability to reduce the risk of exposure to hazardous substances derived from experimental materials. Furthermore, using Augmented Reality in practicum decreases the chance of damage to laboratory tools and materials, which causes students to be afraid and worried because tools and materials in chemistry laboratories are costly.

The exposure and phenomena described above are the reasons and background for conducting research related to “Development of Augmented Reality-assisted Practicum Guidance Media on Thermochemical Practicum”.

Method

Sample and Research Population

This research was carried out at SMA Negeri 3 Tapung, Kampar Regency, Riau, with students from classes X1, XI IPA 3, and XII IPA 2 participating as participants in qualitative research development, while students of class XI IPA 1 and IPA 2 as research samples in quantitative research effectiveness testing.

Convenience sampling was utilized along with random class selection.

Research Design and Procedures

This research is development research, where this research combines qualitative and quantitative research. The development of Augmented Reality-based practicum guide media was developed using the ADDIE model, where the stages are:

a) *Analysis Stage*

The analysis stage contains interviews and observations to find out the needs in the learning process and see firsthand the problems that occurred in the learning process so that solutions to these problems can be found.

b) *Design Stage*

After identifying the needs for the learning process, the next step is to design the practicum guide. This stage contains activities to adjust the content of the practicum guide to the existing competencies.

c) *Development Stage*

After the practicum guide was designed, the practicum guide was then developed. This stage contains the realization of the design that has been made. This development stage contains an assessment of the feasibility of the practicum guide by media experts, material experts and language experts. The usability assessment by the teacher was also carried out to find out the teacher's views on this practicum guide. The practicum guide was also assessed for readability by students as potential users of this media.

d) *Implementation Stage*

After realizing the design of the practicum guide and having tested its feasibility, usability and readability, then the practicum guide that had been made was implemented to the research sample. This stage is in the form of quantitative research to determine the effectiveness of the practicum guide that has been made towards the student learning process.

Research Instruments

The instruments in this study consisted of a feasibility assessment questionnaire by experts, a usability questionnaire by teachers and a readability questionnaire by students. Meanwhile, to test its effectiveness, a test was conducted using an objective question instrument on thermochemical material.

Data Analysis

Qualitative data obtained from the feasibility, usability and readability questionnaires were analyzed by reducing the data and interpreting the numbers in the questionnaire. Quantitative data in the form of pre-test and post-test data were analyzed using SPSS.

Result and Discussion

The research conducted at SMA Negeri 3 Tapung has the aim of knowing the validity and practicality of Augmented Reality-assisted practicum guide media on thermochemical practicum. The validity of the practicum guide media was seen from the results of validation by material expert validators, media experts and linguists. The practicality of the practicum guide was viewed from the teacher and student response tests. In detail, the stages carried out are:

Analyze (Analysis stage)

The analysis stage began with an analysis of the research topic and progressed to an analysis of the students' needs. The analysis was thorough, beginning with an analysis of past research on the topic at hand and progressing to an examination of students, their nature and character, teachers, and the paradigms used in the teaching environment.

a) *Content Analysis*

The content analysis was carried out by looking at conditions in the field and from several literatures. This study was conducted based on the limited costs, time, and practicum materials. Rosdiana et al. (2019) raised a similar issue about obstacles to building skill competencies. Some of these obstacles include a lack of school facilities and infrastructure, such as teaching materials and learning media. Furthermore, the two media made were determined to be fit for usage after being validated by experts. Anggraini et al. (2020) have highlighted that the barriers to the implementation of practicum activities stem from the chemistry teacher's own motivation.

The matters mentioned have led to the conclusion that laboratory facilities in schools affect the practicum learning process carried out, and can make it easier for students to understand the concepts and theories that have been taught previously in the form of practical activities, but there are several obstacles in carrying out these practicum activities.

b) *Analysis of Students, Teachers, and Instructional Needs and Outcomes*

At this stage, a field study was conducted on students' learning abilities, attitudes and characteristics. The location of SMA Negeri 3 Tapung, which is located in a transmigration area, causes students to have different backgrounds and characters and different ways of learning. Based on the results of interviews with the chemistry teacher, it was found that students have a competitive spirit towards academic activities that have

not been maximized and need to be directed. The interview also brought up the fact that in teaching, the teacher had to deliver the material relatively slower than necessary.

The teacher conducted the lesson slowly to ensure that the students understood comprehended the subject presented. This is encouraged by schools that do not require the subject teacher to finish the material in one semester. The impact that can be observed when conducting this research is that some crucial concepts, such as the concept of moles, were not given to the students, causing them to become confused. Student confusion is exacerbated by the failure to perform practicum activities at school due to a lack of practicum tools and materials. Chemistry and practicum are inseparable because practice helps students understand previously taught theory. In addition, practicum allows students to interact directly with chemistry itself. Therefore, the unavailability of laboratories causes students to have difficulty understanding chemical material because they can only envision without seeing the chemical process directly. The non-implementation of practicum activities is due to the unavailability of supporting facilities in conducting practicum such as tools and materials, hence the need to find solutions that can overcome this problem. Technology that is developing rapidly at the present time can be a solution to this problem. Augmented Reality is one of the innovations in the field of technology that can be utilized for various fields, one of which is in the field of education. Practicum can be done using the help of augmented reality so that even without tools and materials, practicum can be done.

Design (Design Stage)

The researcher first reviewed basic competencies, which include two points: competency 3.4, which explains the concept of enthalpy change of reaction at fixed pressure in thermochemical equations, and competency 3.5, which explains the type of enthalpy of reaction, the Hess law, and the concept of bond energy. The designed practicum guide lists these basic competences. Furthermore, media preparation was accomplished by reviewing basic competencies and incorporating the material into the theoretical foundation of the practical guide. During this step, the researcher also created a storyboard with an overview of the media developed (Nurfadhillah, 2021). During this stage, the researcher determined the expert who became the validator for the developed media. The selection of validators was based on certain criteria, that is: a person who understands chemistry and technology.

Development (Development Stage)

At this stage, media that had been tailored to the core and basic competencies was developed. The media produced was an Augmented Reality-assisted practicum guide. Based on the story board guidelines, an initial design of the practicum guide was created using the Canva application, following the reference guide for preparing the existing practicum guide. The practical guide generated contains the same components as other practical guides, with the exception of photographs that may be scanned to display Augmented Reality and a validation sheet indicating that the practical guide developed has been validated by experts and can be used in research.

Figure 1. Preliminary Design of Practical Guide assisted by Augmented Reality

This stage also contains assessment steps by experts to obtain expert judgment on the empirical validity of the developed media. The number of experts, also known as validators, in this study was five, each of whom were all lecturers at different universities. The media aspect was reviewed by two individuals, the material aspect by two people, and the language aspect by one more validator. The assessment was conducted using a questionnaire with a Likert scale, which was then calculated and analyzed. The results were then interpreted using the validity and practicality interpretation tables.

Table 1. Validation results of the material

Criteria	Percentage	Information
Content Suitability Aspect	80	Valid
Presentation Feasibility Aspect	80	Valid
Language Eligibility Aspects	78	Valid
Percentage	80	Valid

In the table above, it can be seen that the assessment by 2 validators in terms of material obtained a result of 80%. Based on the interpretation table, this percentage is included in the valid category.

Table 2. Validation results of the media

Criteria	Percentage	Information
Graphic Feasibility Aspects	79	Valid
Aspects of Using Augmented Reality Technology	81	Valid
Percentage	80	Valid

The table above shows that the assessment by two validators in terms of media yielded a result of 79,6%. Based on the interpretation table, this percentage falls into the valid category.

Table 3. Validation results of the language

Criteria	Percentage	Information
Language Eligibility Aspects	100	Very valid
Percentage	100	Very valid

The table above shows that the assessment by one validator in terms of language obtained a 100% result. Based on the interpretation table, this percentage falls into the highly valid category. After being assessed by experts, then the media was tested for readability or practicality by the teachers and students. The teachers involved in this test amounted to 2 people, while the students involved came from grades X, XI and XII which totaled 35 people with the aim of seeing the response to prospective users of the practicum guide.

Table 4. Practicality Results by Chemistry Teachers

Criteria	Percentage	Information
Physical Appearance	88.3	Very valid
Material Presentation Techniques	86.6	Very valid
Language Used	81.6	Very valid
Aspects of Using Augmented Reality Technology	86.0	Very valid
Percentage	86.0	Very valid

In the table above, it can be seen that the assessment by 2 teachers in terms of practicality obtained a result of 85,5%. Based on the interpretation table, this percentage is included in the highly valid category.

Table 5. Practicality Results by Students in Small-Scale Testing

Criteria	Percentage	Information
Student Response	82	Very valid

In the table above, it can be seen that the assessment by 35 students in terms of practicality obtained a result of 82%. Based on the interpretation table, this percentage is included in the highly valid category. Based on the assessment that has been carried out, the practicum guide can be used at the implementation stage.

Implementation (Implementation Stage)

The practicum guide that had gone through the validity and practicality assessment stages by experts, teachers and students, was then implemented into the experimental class, which was the XI IPA 2 class to assess its practicality by students. At this stage, a practicality assessment of 82% was obtained which was included in the highly valid category. The practicum guide was implemented in the learning process of thermochemistry in the experimental class. While the control class only used the standard practicum guide, the experimental class did not use it.

Table 6. Practicality Results by Students in Large-Scale Testing

Criteria	Percentage	Information
Student Response	82	Very valid

Evaluation (Evaluation Stage)

This step used the quasi-experimental method with the Non-equivalent Control Group Design type, in which treatment was given to the experimental group while a control group was also provided for comparison. Each group received a pretest and post-test, after which the experimental group was treated with Augmented Reality-assisted practicum guide media (Lubis, 2021). The participants in this study were XI MIPA class students of SMA Negeri 3 Tapung during the 2022/2023 school year. The sampling size was 37 people, and the sampling approach was simple random sampling, which means that samples were taken at random. Data were collected using a multiple-choice test instrument of 9 questions that had been tested for validity, reliability, difficulty level and differentiation (Nasution, 2019). Tests are conducted to determine the level of success of the student learning process (Arikunto, 2006). The prerequisite tests used to analyze variance are normality test and homogeneity test. The hypotheses in this study are

Ho : There is no difference in student learning outcomes in learning chemistry between classes that do or do not apply Augmented Reality-assisted practicum guide media in thermochemical practicum.

Ha : There is a difference in student learning outcomes in learning chemistry between classes that do or do not apply Augmented Reality-assisted practicum guide media in thermochemical practicum.

Hypothesis testing was carried out using the MannWhitney test formula with the aim of knowing the learning outcomes of students between the experimental class and the control class (Suharti et al., 2021)). Hypothesis testing can be determined based on the Ucount and Utabel comparison criteria (Indihartati, 2022).

The class to be sampled must be determined in accordance with the applicable requirements, which require that the class be homogeneous. Thus, the homogeneity test was performed first. Because there were two or more variations in this study, the Bartlett test was used to determine homogeneity. The processed data came from the students' hydrocarbon material test results. Data is considered homogenous if the estimated Chi squared value is less than the Chi squared table (Irham et al., 2021). In this case, the computed Chi squared value was 3,41. Meanwhile, the Chi squared table with df=31 resulted in a value of 44,98. Therefore, 3,41 < 44,98, indicating that the sample was from a homogeneous population and may be utilized as a sample.

Referring to the data obtained from the pre-test and post-test results in the table above, it is known that the X2count value is 38,648.76 and the X2table value is 9,485. This means that X2count> than X2table and it can be concluded that the data from the pre-test and post-test scores of students for both sample classes are not normally distributed. Thus, with these results, the next test carried out was a non-parametric test, namely the MannWhitney U test. Based on the data obtained, it shows that the calculated Chi squared value is greater than the Chi squared table. In this case the Chi squared table value is 100,74 because it has a df of 79. Whereas the calculated Chi squared value is 506.529. Thus 506,529 > 529, it can be concluded that the data obtained is not homogeneous.

According to Sugiyono (2015), if Ucount is less than Utabel, then Ho is rejected and Ha is accepted. The Mann-Whitney test yielded a Ucount value of -132. This value is less than the Utabel, which is 123. The table above shows that Ucount < Utabel. As a result, based on hypothesis decision making, H0 is rejected and Ha is accepted. It can be concluded that there is a difference in student learning outcomes in chemistry between classes that use or do not use Augmented Reality-assisted practicum guide media in the thermochemical practicum.

Augmented reality is a modern technical breakthrough that is favored among students at the school level, ranging from elementary school to high school. Augmented Reality, particularly when used in secondary schools, has the potential to improve student interest and activeness (Yilmaz, 2018). Increased student interest in the learning process is evidenced by research conducted on one of the materials in science subjects. This study found that the interest of students who used Augmented Reality media increased along with their understanding (Rosma Aryani et al., 2019). Interest and understanding are inseparable. Students that are interested will be more likely to follow the learning process. Interesting media will stimulate students' interest in studying, consequently boosting their comprehension (Sirait, 2016). Students at SMA Negeri 3 Tapung likewise experienced the aforementioned explanation, and they appeared eager when using the practicum guide media using Augmented Reality. Students' interest for Augmented Reality-assisted practicum media influences how they learn, since students actively participate in learning and closely observe practicum through Augmented Reality. This enthusiasm has an impact on student comprehension of thermochemical material animated by Augmented Reality through practical approaches, which increases and influences student learning outcomes. The learning process carried out by students in groups also increases interaction between students and strengthens the potential that exists within them.

The improvement in student learning outcomes at SMA Negeri 3 Tapung as seen from the results of the students' post-test shows that the Augmented Reality-assisted practicum guide media is in accordance with the results of previous studies on Augmented Reality, which shows that there is an increase in post-test results after learning is done using Augmented Reality (Sumardani et al., 2019). Other Augmented Reality research was conducted regarding a planetary motion material, which is a material found in physics. In addition to improving understanding, Augmented Reality has been shown to boost students' partial skills, which include creativity, imaginative power, and problem-solving skills (Arifin et al., 2020). Some of the qualities required by the millennial generation to face the twenty-first century, such as critical thinking, communication, collaboration, creativity, and innovation, can be concluded from some analysis that the media is appropriate for strengthening students' 4C skills (Elisa & Wiratmaja, 2019).

Conclusion

The validity of Augmented Reality-assisted practicum guide media is 86,5%, indicating a highly valid category. The practicality of Augmented Reality-assisted practicum media among chemistry teachers is 85,6%, placing it in the highly practical category. The

practicality of Augmented Reality-assisted practicum media, as determined by student responses, is 82%, placing it in the highly practical category. Based on the results of the validity and practicality tests, it can be concluded that the Augmented Reality-assisted practicum guide for thermochemical practicum is highly feasible and practical for use in the thermochemistry learning process.

According to the findings of the research, Augmented Reality-assisted practicum guide media is effective for use in the thermochemistry learning process as there are differences in student learning outcomes between those who use Augmented Reality-assisted practicum guide media and those who do not, with a Ucount value of -132.

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Author Contributions

F., contributed in conceptualizing the research idea. P. S supervisor who reviewing, and editing the article. H. S who have provided suggestions and input to the development of practical guide assisted Augmented Reality in implementation of research. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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