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Development of Green Chemistry Physics Practical Worksheet Based on Case Method in Chemistry Education Study Program

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Abstract: This development research aims to develop LKM green chemistry physics chemistry practical worksheet based on case method as supplementary teaching materials for students of the Chemical Education study program at Sriwijaya University using the 4STMD (Four Step Teaching Materials Development) method. The steps of the 4STMD method, namely the first stage is the selection stage, carried out by analyzing needs, curriculum and analyzing the material by looking for references in various sources. The second stage, namely the structuring stage, is carried out by adding or subtracting material and compiling the material. The third stage is the characterization stage, carried out by developing the results of material analysis. The fourth stage is the didactic reduction stage, but the researcher did not carry out the didactic reduction stage. Data collection techniques used in the form of interviews, pre-research questionnaires and validation questionnaires. In the material validation test, the validity of teaching materials was obtained based on the Aiken coefficient of 0.75 which was categorized as high. Based on these results, it shows that the development of LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method has met the valid criteria.

Keywords: Constructivism needham's 5-phases; Qualitative analysis of protein; Student perception

Introduction

Chemistry presents varying levels of complexity related to abstract concepts, the use of symbols, and chemical reactions (Dood et al., 2022; Ahmar et al., 2020; Bernholt & Parchmann, 2011; Taber, 2009). The goal of learning chemistry in high school is to ensure that students have a strong understanding of chemical concepts and the ability to relate and apply them to everyday life and technology (Vachliotis et al., 2021; Nurkholik & Yonata, 2020; Nieswandt, 2007). Komariah et al. (2024), Lee et al. (2016), and Wahyuningsih et al. (2017) proposed that steps to create more sustainable education not only require adequate teacher skills and expertise, but also involve the integration of Education for Sustainable Development (ESD) into the learning curriculum. ESD is an educational approach that aims to apply the concept of sustainable development, which aims to improve understanding and skills in maintaining environmental sustainability for the future (Martín-Sánchez et al., 2022; Tukan et al., 2020; Kopnina, 2018).

ESD in chemistry learning can be applied through the concept of green chemistry which is closely related to handling environmental problems. The 12 principles of green chemistry are expected to respond to challenges around pollution, energy crises, waste, and work safety (Ardila-Fierro & Hernández 2021; Ivanković et al., 2017).

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Through the green chemistry aspect, chemists have demonstrated their ability to design products that are not only beneficial to humans, but also environmentally friendly (Zuin et al., 2021; Abdussalam-Mohammed et al., 2020; Beach & Anastas, 2009). The development of green chemistry in chemistry studies is still relatively new, where chemistry learning is often associated with the use of hazardous chemicals that are not environmentally friendly (Andraos & Matlack, 2022; Johnson et al., 2020). Green chemistry offers an alternative to reduce the use or manufacture of potentially hazardous materials that can endanger the health of living things and damage the environment (Kar et al., 2021; Chen et al., 2020). In the context of chemistry learning, green chemistry can be applied through the development of learning modules, learning models, and more environmentally friendly practicums (Sari & Atun, 2023; Lewi & Listyarini, 2022; Darwis et al., 2021).

Applying the principles of green chemistry in chemistry learning is expected to be a suitable option to promote an environmentally focused chemistry learning approach and create safe working conditions in the laboratory. Previous research by Adela et al. (2022) and Yeagley et al. (2016) showed that green chemistry practicum learning effectively improves student learning outcomes, provides safety, reduces the production of hazardous chemical waste, and saves costs by using easily available and affordable materials (Idrus et al., 2020). Another study by Redhana et al. (2020) and Amaliyah et al. (2024) concluded that students showed a good and very positive attitude towards interest in learning chemistry when doing green chemistry practicums.

Based on the results of an interview with one of the lecturers of the Physical Chemistry Practicum 1 course at the Chemistry Education Study Program, FKIP, Sriwijaya University, it was explained that the availability of LKM already exists but still uses synthetic chemicals with high toxicity levels. These materials are also expensive with limited availability and no waste processing technology. This study is expected to use LKM based on green chemistry that is safe, easy to use, and environmentally friendly. In addition to training students' science process skills, it can also train students' skills in solving environmental problems and utilizing environmentally friendly natural materials.

Based on the research above, it is necessary to develop a Physical Chemistry Practicum LKM for students of the Chemistry Education Study Program, FKIP, Sriwijaya University which can support and overcome problems in practicum activities. Therefore, the researcher is interested in conducting research with the title "Development of Green Chemistry Physical Chemistry Practicum LKM Based on the Case Method of the Chemistry Education Study Program, FKIP, Sriwijaya University".

Method

The type of research carried out by the researcher is Development Research with a qualitative approach to produce certain products, namely the development of LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method using the 4STMD (Four Steps Teaching Material Development) model or method.

The research subjects were chemistry education students class 2023 FKIP Sriwijaya University who had taken Chemistry Physics courses. The object of this research is the development of LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method using the 4STMD method.

In this research procedure, the researcher developed LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method with the 4S TMD (Four Steps Teaching Material Development) development model that had been developed by Anwar (2019) which had four stages, namely selection, structuring, characterization and didactic reduction. only do the selection, structuring and characterization (Fitriah et al., 2023; Khoirunnisa et al., 2023; Juwita et al., 2024).

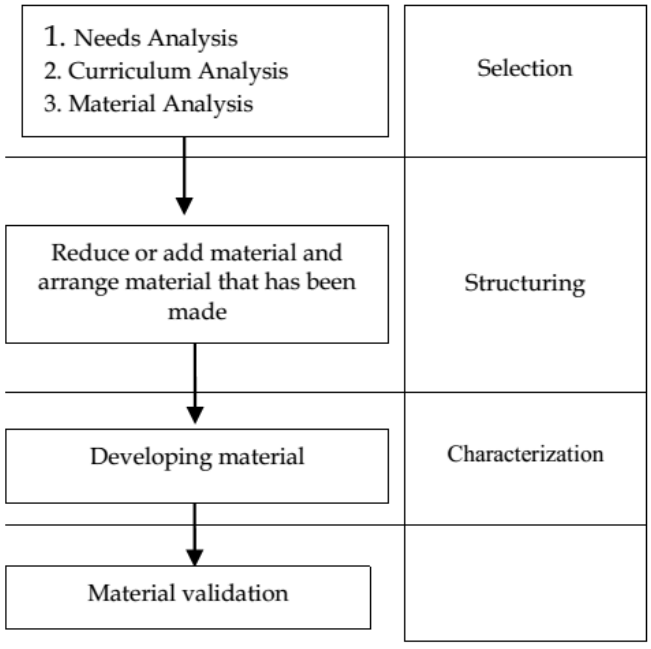

Figure 1. Research procedure

The data collection technique carried out by researchers through interviews was carried out on lecturers of LKM Green Chemistry Physics Chemistry

Practical Worksheet Based on Case Method at the Chemistry Education Study Program, FKIP Sriwijaya University to find out the problems contained in the study of Physics Chemistry. Pre-research questionnaire, given to 2023 class chemistry education students who have taken Physics Chemistry with the aim of analyzing student needs and material validation. Data analysis uses Aiken's V statistics to determine material validity. The following is the formula from Aiken's in Azwar (2012).

$$V= \Sigma s/[n(c-1)] \quad (1)$$

Information:
s : r-lo
lo : the lowest score of validity
c : the highest validity rating score
r : the number given by the rater

The results of the V 'Aiken scores are interpreted into the questionnaire score interpretation criteria as shown in Table 1.

Table 1. Categories of Teaching Material Validity (Azwar, 2012)

Items	V Value	Category
1	0.00–0.33	Low
2	0.34–0.67	Medium
3	0.68–100	High

Result and Discussion

Selection Stage
Needs Analysis

The needs analysis was carried out by distributing pre-research questionnaires to the 2023 batch of FKIP chemical education students who took Physics Chemistry courses. Based on a pre-research questionnaire conducted by researchers to students, students need other teaching resources that can help learning in Physics Chemistry courses. The results of the 2023 chemistry education student questionnaire distribution showed that: as many as 80% of students stated that Physics Chemistry were difficult subjects to understand; as many as 91.4% of students liked to seek references from other sources; as many as 97% of students stated that students need material development in order to help fulfill learning resources on Physics Chemistry. The results of the questionnaire above are that it is necessary to develop LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method to meet student learning needs.

Curriculum Analysis

Researchers analyzed whether there was a change in the curriculum in the FKIP chemistry education study program. Based on the results of the analysis, the chemistry education curriculum of FKIP Unsri used was the revised 2017 curriculum. In addition, the researchers conducted an analysis of the RPS (Semester Program Plan) for Physics Chemistry. Based on the RPS, it is known that odd semester students are expected to be able to understand the physics chemistry.

Material Analysis

Researchers analyze material on teaching materials or e-books that have been used as references by looking for other references such as journals, articles, books and other teaching materials (Agarwal & Pandey, 2013; Nguyen, 2015; Pannen & Purwanto, 2001; Tarigan & Tarigan, 2009). So that researchers can choose which references are appropriate to be used as material development.

Structuring Stage

At this stage the researcher compiles the material that has been selected or analyzed according to the e-book reference that has been given. The arrangement of the material is related to the format in the e-book, and adding or subtracting the material.

Characterization Stage

After conducting the selection and structuring, the researcher carried out the characterization stage where the researcher developed the material that had been compiled using his own sentences.

Material Validation

After the researcher developed the material, the next step was to validate the material with the aim of knowing the validity of the product being developed.

Table 2. Validation Process Improvement Results

Items	Comments	Suggestions for Improvement
1	The concept map should be clear	Fixed according to suggestions
2	In the introduction, sub-CPMK no longer writes understanding	In the introduction to the sub-CPMK only write explaining
3	Fix captions on images	The caption on the picture has been fixed
4	Scientific writing must be italicized	Fixed according to suggestions

The results of the validation questionnaire were then calculated using V 'Aiken. Can be seen in Table 3.

Table 3. Calculation of V 'Aiken

Expert	Descriptor	r	s	Σs	Aiken's value	
1	16	35	72	14	0.75	High
2	16	37	72	4		

Based on the results of the V Aiken calculation, it produces a value of 0.75 which is categorized as high according to the table of categories for the validity of teaching materials.

Conclusion

The development of LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method as a supplement for teaching materials was developed using the 4STMD method which has four stages. The first stage is the selection stage, carried out by analyzing the needs, curriculum and analyzing the material by looking for references in various sources. The second stage is the structuring stage, carried out by adding or subtracting materials and compiling the materials. The third stage is the characterization stage, carried out by developing the results of material analysis. The fourth stage is the didactic reduction stage, but the researcher did not carry out the didactic reduction stage. The development of LKM Green Chemistry Physics Chemistry Practical Worksheet Based on Case Method was developed using the 4STMD method met the valid criteria. In the analysis of material validity data, the average value of 0.75 is categorized as high or declared valid.

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Author Contributions
The authors in this research are divided into executor and advisor.

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Conflicts of Interest
All author declares that there is no conflict of interest.

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