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Development of Integrated Instrument Components of Chemistry Practicum for Acid-Base & Organic Reaction Topics with Green Chemistry Approach

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Chemistry is a practical subject, not only studied through textbooks but also through practicums. However, practical activities are rarely carried out in schools. This is due to several factors, such as the unavailability of a laboratory, inadequate practical manuals, and the emergence of practical waste, which is dangerous for the environment. This research aims to develop an integrated instrument component (KIT) for chemistry practicum with a green chemistry approach for acid-base & organic reactions and determine its suitability. The research and development (R&D) method used in this research is the 4D model proposed by S. Thiagarajan, Dorothy S. Semmel and Melvyn I., which contains four stages: definition, design, development and dissemination. Due to limited research capabilities and time, this research could only reach the development stage, namely validation testing, carried out by Chemistry Lecturers at the State University of Malang and Chemistry Teachers at SMAN 1 Pasirian. The results of this research are an integrated instrument component product (KIT) for chemistry practicum, which contains a toolbox and materials and a practicum guide that includes educational videos. The average percentage of media validation results for this practicum's integrated instrument components (KIT) reached 92.33%, with a very feasible category. The students' positive response to the practicum integrated instrument (KIT) component with an average percentage of 90.97% with excellent criteria. It is hoped that the results of this development can become an alternative medium for learning chemistry that makes it easier for students to master chemistry material, especially on the topics of acid-base and organic reactions.

Graphical abstract

Keywords

Integrated Instrument Components
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Acid-Base
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1. Introduction

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Chemistry is a practical subject, not only learned through textbooks but also through practicum. Chemistry consists of two aspects that have a close and interrelated relationship, namely chemistry as a result (in the form of

chemical facts, concepts, theories, and principles) and chemistry as a procedure (involving the scientific method) [1]. In the independent curriculum, chemistry learning is divided into phases E and F. Phase E is a transitional stage for students from junior high to senior high school (grade 10), where students must recognize their potential and talents before entering a higher grade. In this phase, students are given a focus on several introductory subjects. One of the elective subjects available is chemistry. Phase F, however, is designed for grades 11 and 12 of senior high school. At this stage, students can choose subjects they enjoy, or that align with their interests and talents. Implementing the independent curriculum in high schools is expected to encourage students to become critical and open-minded individuals through scientific practices and strengthen their character based on the values of Pancasila [2]. Realizing these learning outcomes involves chemistry as an outcome and chemistry as a procedure. Chemistry learning that has occurred so far has only emphasized chemistry as a result, and practicum activities are rarely carried out in schools [3]. The practicum will make it easier for students to master chemical material, attract attention, encourage student learning, and providing direct chemical practice experience for students [4]. Practical activities are rarely carried out in schools due to several factors, such as the unavailability of laboratories, inadequate practicum manuals, and the emergence of practicum waste that harms the environment.

Practical activities in learning certainly require a laboratory. A school laboratory is necessary, especially in high schools/equivalents for chemistry learning. However, the reality is that many schools still do not have adequate chemistry laboratories, based on observations and interviews with one of the teachers at SMAN 1 Pasiran conducted by the researcher. It was found that the chemistry laboratory at the high school has inadequate facilities in several aspects, including 1) limited availability and condition of practical equipment and materials, with most of them damaged, 2) laboratory assistants lack understanding of work procedures and occupational safety and health (OSH) in the laboratory, and 3) limited administration of practical equipment and materials, as well as the effectiveness of laboratory use. This is supported by findings from other schools, such as SMA Kabupaten Lebak [5] and SMAN Lombok Tengah [6]. These two studies found that the chemistry laboratories in both schools still had substandard scores, with respective percentages of 39.8% and 62.33%. A study conducted at SMAN 3 Singaraja revealed that while the chemistry laboratory is equipped with complete equipment and materials, it is primarily used for non-practical learning processes [7]. The findings outlined above undoubtedly constitute obstacles that hinder the implementation of practical experiments at schools.

Furthermore, the availability of practical experiment manuals is also necessary. These manuals, which should guide students in conducting scientific work to develop skills aligned with the learning outcomes outlined in the curriculum, currently remain theoretical verification tools and recipe books [8]. Practical work inevitably produces waste. Chemical waste from practical work has the potential to be hazardous and toxic to humans and the environment, both directly and indirectly [9]. This waste can originate from using hazardous chemicals, improper disposal and management processes, and a lack of awareness of the environmental impacts of laboratory activities. This situation is exacerbated by the lack of awareness among educational institutions regarding the negative impacts of directly disposing of chemical laboratory waste in nearby waterways [10]. One alternative solution to the abovementioned issues is using integrated instrument components (KIT) as a chemical laboratory learning medium with a green chemistry approach.

The integrated instrument component, hereinafter referred to as practicum KIT, is equipment developed in a set of learning boxes containing various materials and tools to evaluate students' process skills in the field of science and also equipped with instructions on how to use them [11]. This practicum KIT media is effective and suitable for application in chemistry learning. Practical KIT, which has an instruction manual that applies guided inquiry on acid-base, is very suitable for use in teaching and learning activities [12]. Through this practical KIT, students will better understand chemistry material and improve science process skills by the demands of the independent curriculum. Instruction books and practicum kits are effectively used in learning by showing high cognitive, skill, and attitude learning outcomes [13]. The use of chemistry lab kits as a tool in learning has proven effective in developing science process skills (KPS) among grade X high school students [14].

Meanwhile, the green chemistry approach is an effort to encourage the development, manufacture, and utilization of chemical procedures and products that limit or even do not use hazardous chemicals [15]. Green chemistry must be applied in practicum activities to reduce the negative impact on the environment and contribute to achieving Sustainable Development Goals (SDGs). This practicum KIT with a green chemistry approach is a series of tools and materials designed in a set of learning boxes to carry out chemical practicum activities by applying the principles of green chemistry accompanied by a user manual. The application of practicum accompanied by a green chemistry-based practicum module positively impacts the environment and helps maintain the harmony of human relations with the environment [16]. Therefore, KIT practical media with a green chemistry approach can be an alternative learning media solution that helps students conduct practical classes and reduces the use of harmful chemicals.

This practical kit with a green chemistry approach was developed for the topics of acids and bases and organic reactions. Both topics, which are part of organic chemistry, are still considered difficult by students due to their complex and abstract nature [17, 18]. Based on a needs analysis conducted at SMAN 1 Pasirian, 68.25% of 63 students reported difficulty mastering acid-base and organic reaction topics. With its complex and abstract concepts, chemistry is one reason students find it challenging to learn chemistry [19]. The acid-base and organic reaction material contains much factual, conceptual, and procedural knowledge [20]. One of the subtopics of acids and bases is acid-base titration. In studying acid-base titration, understanding various basic chemistry concepts is required, including the behavior of particles, atomic structure, ionization potential, and [21]. In the acid-base titration material, students are expected to be able to describe the neutralization process as a physical mixture of acids and bases found in everyday life. Therefore, in studying this material, practical activities are needed to support students in gaining maximum understanding and applying this understanding in everyday life. Initial observations of 63 students at SMAN 1 Pasiran revealed that 88.89% preferred practical activities because they provided enjoyable learning experiences and were more beneficial, making it easier to understand concepts in chemistry, especially those of a procedural nature. Additionally, practical activities should be taught in the organic reaction material, one of which is the saponification reaction. Saponification is a hydrolysis reaction of fats using strong bases, producing glycerol and fatty acid salts, where the fatty acid salts are known as soap [22]. Through the practical activity of saponification, it is hoped that students will gain direct experience of how the reaction occurs and produces a product used in daily life.

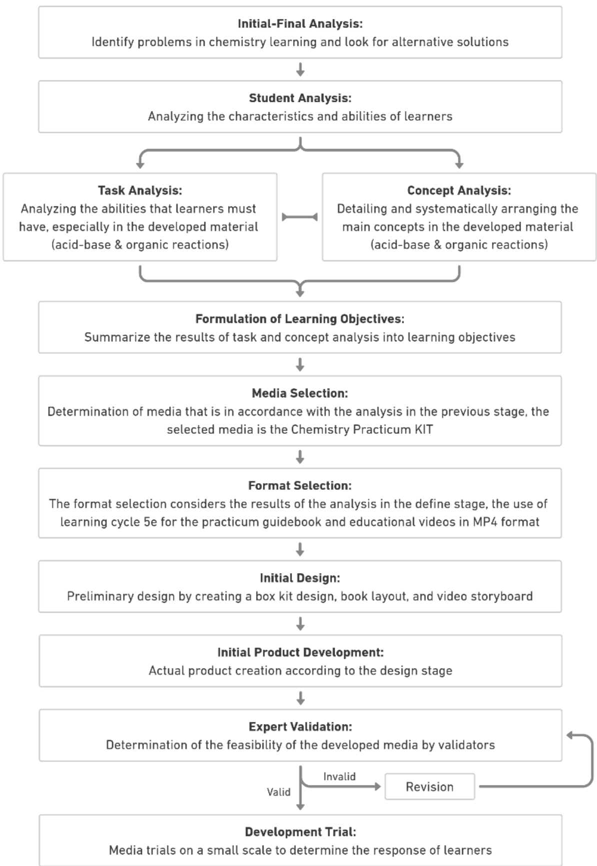


Fig. 2. Stages of research and development of the Chemistry Practicum KIT.

Based on the explanation above, a research idea is proposed to develop a chemistry practicum KIT learning media with a green chemistry approach for acid-base and organic reactions to solve the problems described. Practical KIT, with a green chemistry approach developed on acid-base and organic reactions, is expected to be an attractive, practical, and easy-to-use media by students and reduce hazardous and toxic practicum waste because it uses environmentally friendly materials. This study aimed to develop and determine the feasibility of chemistry practicum KIT with a green chemistry approach for acid-base and organic reactions. The results of this study are also expected to encourage increased knowledge in innovative, sustainable, and environmentally friendly chemistry learning development to improve the quality of learning, especially in practicum activities.

2. Material and Methods

2.1 Type of Research

The research conducted used the type of research and development (R&D), and it is designed to produce a learning media in the form of an acid-base reaction practicum kit. Component of an integrated instrument of chemistry practicum for the topic of acid-base & organic reactions with a green chemistry approach. The development model used is the 3D model which is adapted from the 4D model proposed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I [23]. This model contains three stages, namely, Define, Design, and Development [23]. This model contains three stages, namely, Define, Design, and Development [24]. The selection of the 3D model also considers the stages of implementation, which are divided in detail and systematically [24] The following are the stages of research and development of the 3D model in Figure 1.

Fig. 1. Chart of Research Method Stages.

C. Define Stage

This definition's purpose is to determine and define the learning conditions that have been applied. At this stage, a series of activities, such as front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives, are carried out.

B. Design Stage

In this study, the planning stage aims to make an initial design of the product to be developed, namely the chemistry practicum KIT. The design of the basic components of the chemistry practicum KIT in the form of a prototype goes through three steps, namely the selection of learning media, the selection of the form of learning presentation or format, and the initial design. Based on the results in the Define stage, researchers chose KIT media, which includes practicum tools and materials, guidebooks, and educational videos (MP4) that apply the principles of green chemistry.

C. Develop Stage

This stage aims to create a chemistry practicum KIT integrated with green chemistry for acid-base materials and organic reactions. After making the product, validation tests and development trials by experts are necessary. The results of these tests, in the form of assessments, suggestions, and comments, are used as a basis for continuing improvements to this chemistry practicum KIT so as to obtain a chemistry practicum KIT suitable for implementation in the teaching and learning process.The steps of the practicum KIT development can briefly be seen in Figure 2 below.

2.2 Type and Collection Instruments

This research contains two types of data: quantitative and qualitative. Quantitative data is in the form of assessment scores from validation questionnaires and student response tests with a Likert scale. Qualitative data is obtained from comments and suggestions contained in the questionnaire. The validation questionnaire and learner response test can be found in the appendix. The Likert scale assessment score is presented in Table 1 below.

Table 1. Likert Scale Score Criteria [25].

Criteria	Score Criteria
Strongly Agree	5
Agree	4
Undecided	3
Disagree	2
Strongly Disagree	1

2.3 Data Anaylysis Techiques

The average analysis technique is a technique used to analyze quantitative data. In this technique, the values given by validators and students will be converted into percentages in the value range 0-100%. The following is the formula for the calculation.

$$P = \frac{\sum x}{\sum x_m} \times 100\%$$

Description:

P = Percentage of feasibility

Σx = Total number of validator / learner assessment scores

Σx_m = Total maximum validation score

The percentage results obtained conclude the feasibility of the chemistry practicum KIT developed based on the validation criteria in Table 2 and the student response test criteria in Table 3 [26].

Table 2. Criteria for Validity [27].

Percentage	Feasibility
81-100	Very feasible
61-80	Feasible
41-60	Moderately feasible
21-40	Less feasible
0-20	Not feasible

Table 3. Learner response test criteria [27].

Percentage	Feasibility
81-100	Very feasible
61-80	Feasible
41-60	Moderately feasible
21-40	Less feasible
0-20	Not feasible

If the percentage of results ≥ 61% is obtained, the developed product is suitable for use as a learning media in teaching and learning activities at school and at home. However, if the result is ≤ 60, then the developed product needs to be revised again

3. Results and Discussion

3.1 Define Stage

Front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives are some of the activities carried out at this stage, which are described below.

A. Front End Analysis

The aim of this step is to analyse the learning conditions and to decide on the problems encountered in learning in the school. Once the problem has been identified, alternative solutions are considered to improve the quality of learning. Based on a literature review, it was found that laboratory activities are rarely carried out in schools and that laboratory equipment and materials are inadequate [28]. In addition, there are still many labs that have not implemented the principles of green chemistry [29]. Inadequate laboratory equipment and materials can be overcome by the availability of laboratory kits, so that practical work can still be carried out. This finding is corroborated by the results of a needs assessment questionnaire conducted at SMAN 1 Pasirian, where 98.41% of the 63 students stated that learning was more often done in the classroom than through practical work in the laboratory. The laboratory at SMAN 1 Pasirian is currently also used as a classroom. This is certainly an obstacle to the implementation of practicals. Practical activities are only conducted once or twice a semester. Although chemistry is practical in nature, it requires practicum activities [30]. The lab manual designed by the chemistry teachers at SMAN 1 Pasirian did not integrate the principles of green chemistry. This certainly results in a lot of waste in the implementation of practicals in schools. Only 15.87% of the 63 students used a Green Chemistry-based lab manual. Based on the statements from the students in SMAN 1 Pasirian, it was also found that the developed lab manual is still verifiable, so there is a need to develop a manual that can help students to develop concepts independently, appropriately and effectively.

B. Student Analysis

Student analysis is useful to recognize the characteristics and abilities of learners. This analysis affects the selection of learning media, models, and instruments of the product to be developed. From this step, it will be known that the teaching and learning process tools are suitable for the conditions and abilities of the learners. Learner review in this study was carried out by filling out a questionnaire by students at SMAN 1 Pasirian. 88.89% of 63 students stated that they prefer practicum activities because it can provide an exciting and more meaningful learning experience so that they are easier to understand the concepts in chemistry. 90.48% of 63 students admitted that it was difficult to master chemistry material. In the questionnaire, it was also found that some students had difficulty memorizing and thinking critically when learning chemistry. The existence of these obstacles can be used as an essential consideration for researchers to develop chemistry practicum KIT that can help students build critical thinking characters through the selection of models and instruments in the practicum guidebook to be developed.

C. Task Analysis

This step aims to analyze the skills that students need to possess, especially in the material to be developed. The selection of development materials is analyzed based on a literature review and learner questionnaires. Based on the students' questionnaire, 68.25% of 63 students stated their difficulty in mastering acid-base and organic reaction materials. In the independent curriculum, learning outcomes are expressed in the form of per-element outcomes in the form of chemical understanding and process skills. The learning outcomes for acid-base materials and organic reactions are presented in Table 4 below.

Table 4. Outcomes per element of chemistry phase F [2].

Chemical Understanding	Process Skills	
Using acid-base concepts in everyday life	1.	Observing
	2.	Questioning and predicting
Understand organic chemistry and its application in daily life.	3.	Planning and conducting investigations
	4.	Processing, analyzing data and information
	5.	Evaluate and reflect
	6.	Communicating results

Based on the learning outcomes listed in the independent curriculum, the abilities that must be present in students must reflect a deep understanding and application of concepts that are relevant to real life. This independent curriculum provides flexibility for schools and teachers in realizing learning strategies that are appropriate to the local context and the needs of students [31]. This can be used as a reference in the development of chemistry practicum KIT on acid-base materials and organic reactions that are interesting and able to improve students' abilities in accordance with the learning outcomes of the independent curriculum.

D. Concept Analysis

Concept analysis is helpful in analyzing, describing, and systematically formulating the main concepts to be explored, especially in acid-base materials and organic reactions. The concepts in acid-base and organic reaction materials are analyzed in detail, especially those that require practical activities. After that, these concepts are taught through practicum activities developed in the chemistry practicum kit. The topics presented in the chemistry lab kit in this study are acid-base titration and saponification reaction. The results of the concept analysis are presented in the concept map as follows in Figure 3 and 4.

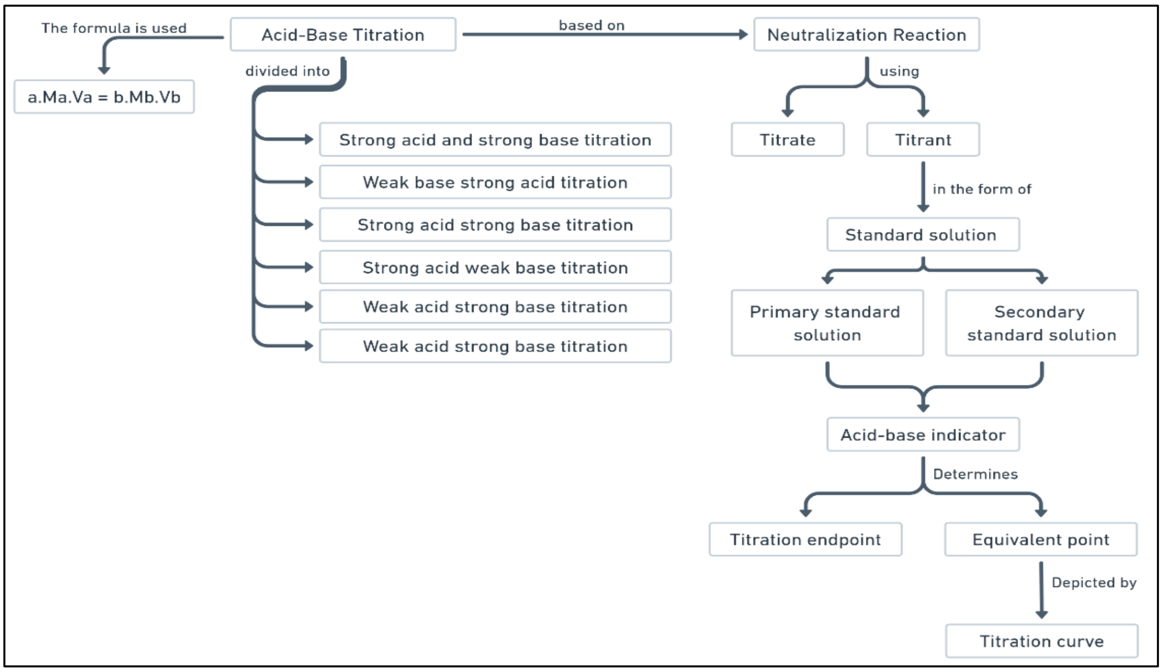


Fig. 3. Concept Map of Acid-Base Titration.

E. Formulation of Learning Objectives

This step is the last stage in the define stage, which aims to summarize the task and concept analysis into a learning objective. In this research, learning objectives are formulated as practicum objectives presented in the practicum guidebook on each topic. This practicum objective is then implemented in each phase of the learning model applied in the practicum guidebook.

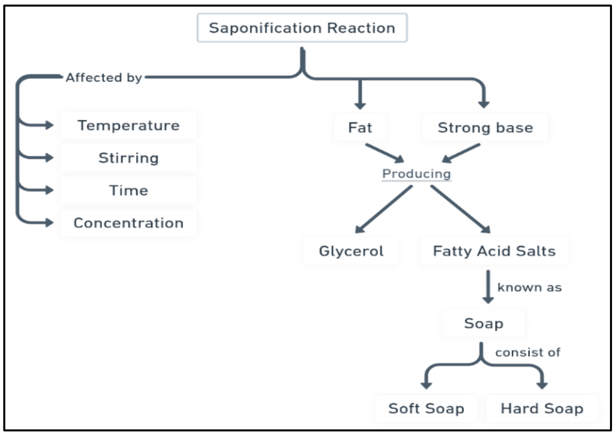


Fig. 4. Saponification Reaction Concept Map.

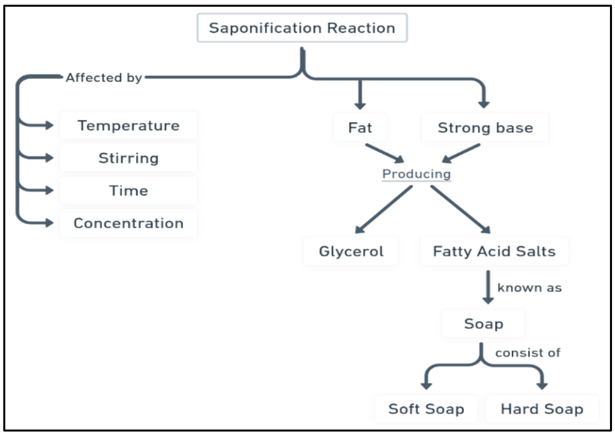


Fig. 4. Saponification Reaction Concept Map.

3.2 Design Stage

In this research, the planning stage aims to make an initial design of the product to be developed, namely the chemistry practicum kit with a green chemistry approach. The design of the basic components of the chemistry practicum KIT in the form of a prototype goes through three steps: the selection of learning media, the selection of the form of learning presentation or format, and the initial design.

A. Media Selection

Problems define the stage, and Media Zealand's action must be in accordance with these problems. In the previous stage, it was found that there were obstacles in the implementation of practicum at school in the form of laboratory use that was not maximized because the laboratory also functioned as a class and the unavailability of practicum manuals integrated with the principles of green chemistry. Based on these problems, the researcher decided to choose the chemistry practicum KIT media, which contained chemistry practicum tools and materials along with a printed book of chemistry practicum guidelines with a green chemistry approach. The use of practicum kits as learning media is considered adequate pra, critical, and easy to use [32]. Chemistry practicum kits can be used in the classroom because they are integrated with the principles of green chemistry. They are expected to work accidents and waste produced [33]; [12].

In addition, the hands-on manual to be developed will also include instructional videos so that students can learn independently after completing the hands-on activities. In this case, of course, it will provide different responses for students, enriching their learning experience and helping to develop students' skills in accordance with what is expected in the independent curriculum.

B. Format Selection

In addition, the practicum guidebook to be developed also includes educational videos so that students can learn independently after carrying out practicum activities. This will undoubtedly provide different responses for students, enrich their learning experience, and help develop students' skills as expected in the independent curriculum. Educational videos are included in the practicum guidebook that will be made in this study. These videos are used in MP4 format because all devices and platforms support this format. The presentation of this educational video is expected to help students interpret concepts in chemistry easily and interestingly.

Based on a series of analyses in the definition stage, problems were found in the form of characteristics of students who find it difficult to memorize and think critically. This problem was taken into account when choosing the format of the Chemical Practicum KIT, especially when preparing the Practicum Guide. The researcher decided to use the Learning Cycle 5E learning model in the preparation of the practicum guidebook and applied the principles of green chemistry. The application of the learning cycle 5E learning model has a positive impact on the development of students' scientific process skills, especially in problem solving and critical thinking [34]. The learning cycle 5E learning model with the stages of engagement, exploration, explanation, elaboration, and evaluation will help students gain a deep understanding of chemical concepts, especially in the acid-base and organic reaction materials developed at KIT in this study. This is also in line with what is expected in the task analysis in the define phase. In addition, to solve problems related to laboratory waste, several green chemistry principles are also implemented, which are outlined in the procedures and use of materials in the chemical laboratory work performed.

The practical manual that will be produced in this study will include an educational video in MP4 format because this format is supported by all devices and platforms. It is hoped that the presentation of this educational video will help students to interpret concepts in chemistry in a simple and interesting way.

C. Initial Design

After selecting the media and format, the initial design of the chemistry practicum kit with a green chemistry approach was made. The initial design of practicum KIT products with a green chemistry approach is divided as follows:

1) Preparation of practicum tools and materials in KIT

The initial design of the preparation of practicum tools and materials in this KIT is in a box, as shown in Figure 5-6.

Practical tools and materials are neatly arranged in a helpful box so that they can be easily carried anywhere. The box used is sized to adjust the size of the tools that will be used in the practicum.

Fig. 5. Display box

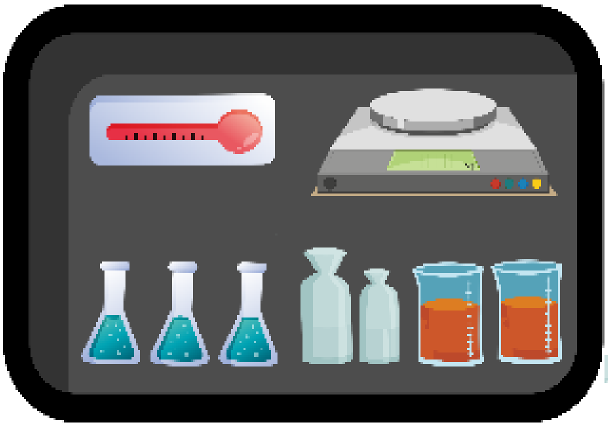


Fig. 6. Inside of the box

2) Layout of the practicum guidebook

The practicum guidebook developed in this KIT is composed of three parts: Introduction, core, and cover. The introductory section consists of the following components: a) The cover page in this section contains the Title of the book and the learning phase of chemistry. b) The foreword provides a glimpse of the background of the practicum guidebook's development and the author's expectations from the book's development. c) Table of contents, containing information on the parts of the practicum guidebook with its pages. d) Laboratory rules contain information about the laws that must be obeyed while in the chemistry laboratory. e) Laboratory safety contains tools that must be worn when working in the laboratory to protect themselves from laboratory work accidents. f) Laboratory equipment contains several pictures and names of laboratory equipment and their functions. g) Laboratory materials containing explanations and MSDS of materials used in acid-base and organic reaction practicum.h) Symbols of hazardous materials contain an explanation of the symbols of dangerous materials that are often found on chemical bottle labels. i) Waste handling contains an explanation of laboratory waste handling procedures so as not to pollute the environment. j) The introduction to practicum KIT contains photos of the KIT boxes for chemistry practicum and their descriptions. cases that students must discuss. h) The evaluation phase contains practice questions from all phases to evaluate students' understanding. i) Educational video barcode. j) The closing section of this practicum guidebook contains a bibliography, glossary, and author profile.

3) Education Video

Fig. 7. Practicum KIT Box.

Fig. 8. Part 1 Practical KIT Box.

The educational video in this practicum guidebook contains material and a discussion of practicum activities that students have done. This video presents an explanation of acid-base material and organic reactions involving multiple chemical representations, namely symbolic, macroscopic, and submicroscopic, which are not dull and are easy for students to understand.

3.3 Development Stage

This stage aims to produce chemistry practicum kits integrated with green chemistry for acid-base and organic reaction materials. After making the product, validation tests were carried out by Chemistry Lecturers at FMIPA State University of Malang and SMAN 1 Pasirian Teachers and development trials at SMAN 1 Pasirian. The results of the test in the form of assessments, comments, and suggestions are used as the basis for improvements to this chemistry practicum KIT so as to obtain a chemistry practicum KIT that is suitable for implementation in the teaching and learning process. The steps at this stage are as follows.

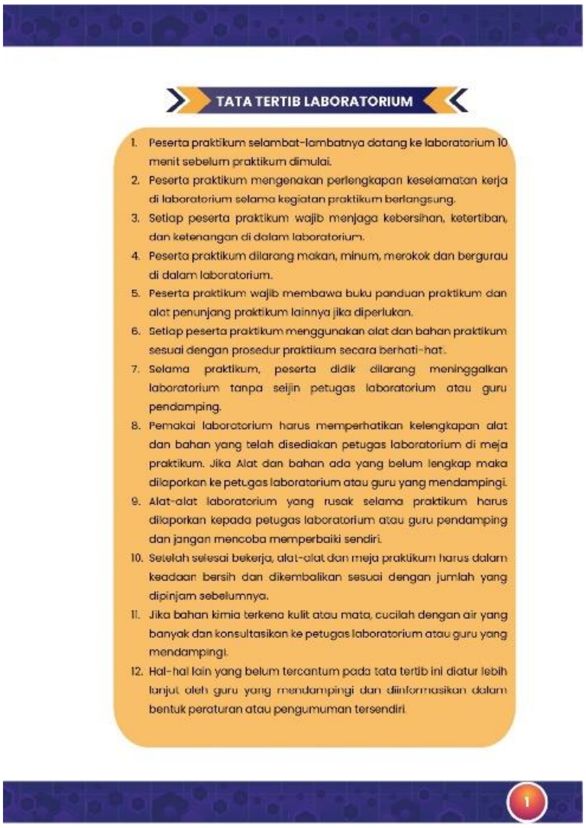
A. Initial product development

Practical KIT products consisting of practicum tools and materials in a box or box by applying green chemistry principles and practicum guidebooks are carried out at this stage. The lab manual also contains educational videos related to acid-base titration material and saponification reactions. The practicum box is made of PP hard Plastic material with a size of 22 x 47.5 x 20.5 cm. In this box, foam with a thickness of 5 cm is used to protect the practicum tools from impact, and this bio foam is formed to adjust the shape of the practicum tools used. The appearance of the box containing practicum tools and materials is shown in Figure 7-9 below.

Fig. 9. Part 2 Practical KIT Box.

The practicum guidebook is divided into three parts: introduction, core, and conclusion. The introductory section contains a title page, preface, table of contents, laboratory rules, laboratory safety, laboratory equipment, laboratory materials, symbols of hazardous materials, waste handling, and introduction to practicum KIT. Some views of the practicum guidebook in the introductory section are in Figure 10-12.

Fig. 10. Guidebook Cover.



TATA TERTIB LABORATORIUM

1. Peserta praktikum selambat-lambatnya datang ke laboratorium 10 menit sebelum praktikum dimulai.
2. Peserta praktikum mengenakan perlengkapan keselamatan kerja di laboratorium selama kegiatan praktikum berlangsung.
3. Setiap peserta praktikum wajib menjaga kebersihan, ketertiban, dan ketenangan di dalam laboratorium.
4. Peserta praktikum dilarang makan, minum, merokok dan bergurau di dalam laboratorium.
5. Peserta praktikum wajib membawa buku panduan praktikum dan alat penunjang praktikum lainnya jika diperlukan.
6. Setiap peserta praktikum menggunakan alat dan bahan praktikum sesuai dengan prosedur praktikum secara berhati-hat.
7. Selama praktikum, peserta didik dilarang meninggalkan laboratorium tanpa seijin petugas laboratorium atau guru pendamping.
8. Pemakai laboratorium harus memperhatikan kelengkapan alat dan bahan yang telah disediakan petugas laboratorium di meja praktikum. Jika Alat dan bahan ada yang belum lengkap maka dilaporkan ke petugas laboratorium atau guru yang mendampingi.
9. Alat-alat laboratorium yang rusak selama praktikum harus dilaporkan kepada petugas laboratorium atau guru pendamping dan jangan mencoba memperbaiki sendiri.
10. Setelah selesai bekerja, alat-alat dan meja praktikum harus dalam keadaan bersih dan dikembalikan sesuai dengan jumlah yang dipinjam sebelumnya.
11. Jika bahan kimia terkena kulit atau mata, cucilah dengan air yang banyak dan konsultasikan ke petugas laboratorium atau guru yang mendampingi.
12. Hal-hal lain yang belum tercantum pada tata tertib ini diatur lebih lanjut oleh guru yang mendampingi dan diinformasikan dalam bentuk peraturan atau pengumuman tersendiri.

1

Fig. 11. Laboratory Code of Conduct.

SIMBOL BAHAN BERBAHAYA

Bahan-bahan kimia yang ada di laboratorium memiliki simbol yang terdapat pada bagian luar wadahnya. Simbol tersebut menunjukkan karakteristik bahan yang terdapat di dalam wadah tersebut. Adanya simbol tersebut bertujuan untuk meminimalisir terjadinya kesaalahan dalam penggunaan bahan tersebut. Selain itu juga untuk mengurangi risiko berbahaya yang terjadi dari bahan kimia tersebut. Adapun beberpa simbol bahan kimia berbahaya sebagai berikut:

No.	Simbol	Arti	Contoh
1.	icsa.co.id	***Irritant* (Iritasi)** bahan yang dapat menyebabkan inflamasi apabila kontak langsung dengan selaput lendir atau kulit. Efek yang ditimbulkan seperti gatal-gatal hingga luka bakar kecil pada kulit.	Natrium hidroksida, toluene, dan isobutanol
2.	icsa.co.id	***Dangerous for the Environment* (Berbahaya untuk Lingkungan)** Bahan kimia yang mampu menyebabkan penurunan kualitas lingkungan dan mengganggu keseimbangan ekologi	Tetraklorometana dan petroleum hidrokarbon

Fig. 12. Hazardous Chemical Symbols.

The core section of the practicum guidebook consists of two practicum topics where each topic is organized based on components including the title of the experiment, learning outcomes, objectives, green chemistry, engagement phase, exploration phase, explanation phase, elaboration phase, evaluation phase, and educational video barcode. Some views of the practicum guidebook in the core section are shown in Figures 13-15.

Fig.13. Practicum Title.

The closing section of the lab manual consists of a bibliography, glossary, and author profile. Some views of the lab manual are in the core section in Figures 16-17.

B. Expert Validation

The products that have been prepared are then checked for validity by experts. The validators of the development of chemistry practicum KIT by applying the principles of green chemistry are one Chemistry Lecturer at FMIPA State University of Malang and one Chemistry Teacher at SMAN 1 Pasirian. The assessment by the validator uses an instrument in the form of a validation questionnaire, which contains aspects of design,usability, content, and language. In addition, comments and suggestions were also given to improve the chemistry practicum KIT with a green chemistry approach so that the KIT is suitable for use in learning. The validation results can be seen in Figure 18.

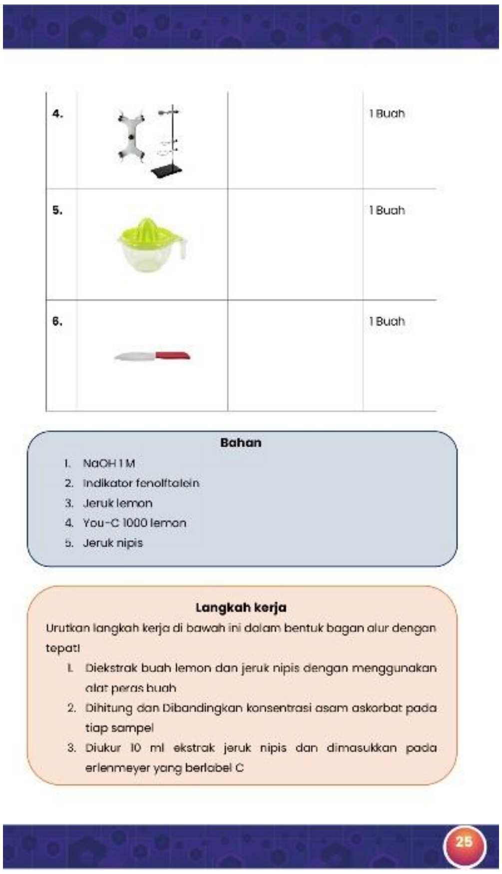


Fig. 14. Exploration Phase.

Fig. 15. Educational Video.

Fig. 16. Bibliography.

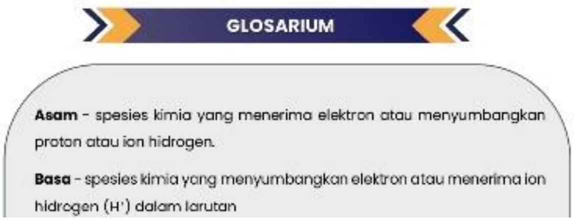


Fig. 17. Glossary.

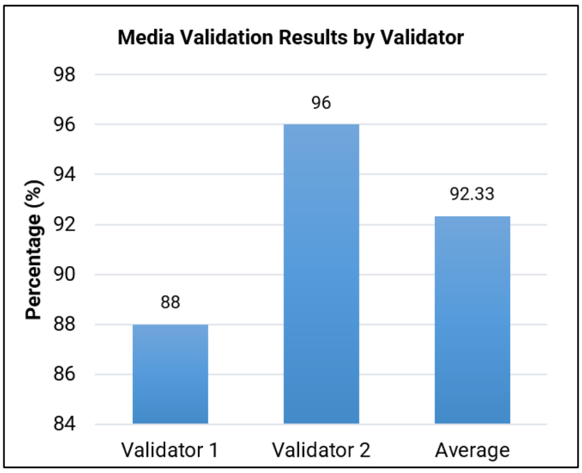


Fig. 18. Media Validation Results by Validator.

Based on Figure 18 above, the percentage of media feasibility obtained was an average of 92.33%, so it can be categorized as very feasible to implement in the teaching and learning process. The results of the validation of each aspect can be seen in Figure 19.

Chemistry practicum KIT, with a green chemistry approach that has been developed in terms of design, usability, content, and language, is in the very feasible category. However, in the validation assessment, several suggestions and comments submitted by the validators were applied to change the media into a more perfect press. The comments and suggestions are presented in Table 5.

Furthermore, the media was revised according to the comments and suggestions described in Table 5.

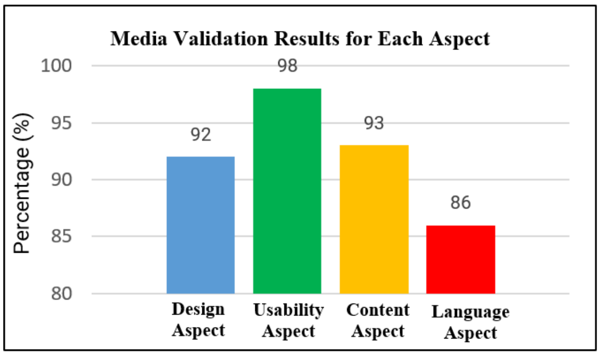


Fig. 19. Media Validation Test Results for Each Aspect.

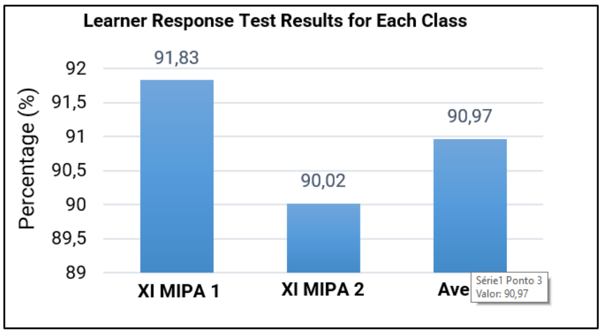


Fig. 20. Results of Media Development Response Test by Learners.

Table 5. Results of Media Validation Comments and Suggestions by Validators.

Validator	***Comments and Suggestions***
V1	1. Correct the irritation symbol in the manual 2. Improve the sentence on the acid-base practicum objectives so that it does not cause ambiguity 3. Eliminate one of the words "on" and "in" for the sentence "based on the reading above, formulate..." 4. Writing the word "indicator" consistently in Indonesian instead of "indicator" 5. Work steps generally use passive voice 6. Changing the word "duplet" to "duplo" 7. Corrected the writing of "H+" to "H^+" 8. Changed the word "noted" to "catatam" 9. Added the word "titration" to the phrase "end point" 10. Capitalized the letter "g" in the word "salt" at the beginning of the sentence in the theory base. 11. Changed the phrase "degree centigrade" to "°C" 12. Changing the capital "p" in the word "solid" to lowercase. 13. Adding stirring observation data to the saponification reaction practicum 14. Changing the phrase "lye solution" to alkaline solution
V2	1. One of the students at SMAN 1 Pasirian has red dominant color blindness so that colors that contrast with red will be difficult to read.

C. Development Trial

Products that have been declared feasible by experts are then continued with development trials. This intends to see the response of students from the KIT that has been developed. This learner response test was carried out on a limited basis on students at SMAN 1 Pasirian, namely in classes XI MIPA 1 and XI MIPA 2, with a total of 65 students. This response test was carried out by conducting a demonstration of chemistry practicum KIT with a green chemistry approach in class and asking students to read the entire practicum guidebook and watch educational videos contained in the practicum guidebook. After that, the response questionnaire from students was filled in to assess using the scale provided and provide comments or suggestions related to the practical KIT that had been prepared. The results of the student response test in each class can be seen in Figure 20 below.

Figure 20 shows that the average percentage of student responses for class XI MIPA 1 reached 91.83%, and class XI MIPA 2 reached 90.02%. The average student response test results reached 90.97%, which shows that the developed media is included in the very good category. The results of the students' response test to each aspect can be found in Figure 21.

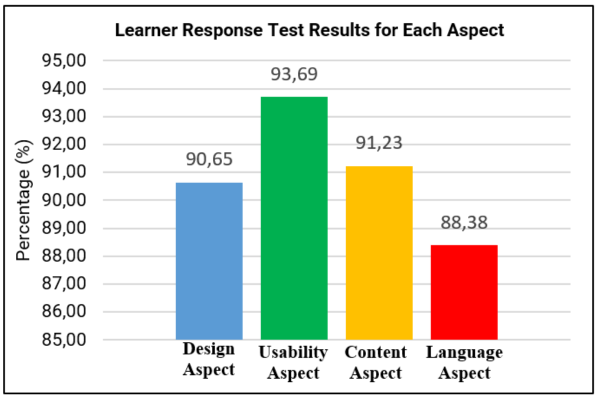


Fig. 21. Results of Media Development Response Test by Learners.

Based on Figure 21, it can be seen that for the design aspect, the percentage reached 90.65%, the usability aspect reached 93.69%, the content aspect reached 91.23%, and the language aspect reached 88.38%. All aspects of the development of chemistry practicum KIT media with this green chemistry approach, according to the results of the student response test, are included in the outstanding category. The existence of chemistry practicum KIT media with this green chemistry approach received a positive response from students of SMAN 1 Pasirian. This is supported by suggestions and comments written by students, stating that the practicum KIT that has been made is easy to understand, practical, and enjoyable, so it is suitable for students learning chemistry. This practical KIT can be implemented as a learning media that is feasible and well-received by students to facilitate the learning process and understanding of chemical materials, especially acid-base materials, and organic reactions

4. Conclusions

Based on the explanation of a series of research processes from the definition to the development stage, it can be concluded that the chemistry practicum kit with a green chemistry approach for the topic of acid-base and organic reactions is a learning media that is very feasible to be implemented in the teaching and learning process, with an average percentage of feasibility reaching 92.33%. The student response test also showed positive results, with an average percentage reaching 90.97%, including in the outstanding category. The developed media can be a learning alternative that makes it easier for educators to explain chemistry material and students to get a better understanding of the material, mainly regarding acid-base and organic reactions.

Author Contributions

Agustin Tria Retnani has developed the concept of the research, provided visualization, conducted investigations, and performed formal analysis. Dhimas Bagus Kurniawan has provided visualization drafted and written the manuscript. Ubed Sonai Fahruddin Arrozi has supervised this research and reviewed and edited the final draft.

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