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Development of Small-Scale Kits and Flipbooks for Practical Acid-Base Instruction

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Abstract: Practicum is essential to learning because it provides practical learning opportunities in building students' knowledge. Learning using the practical method can explain abstract theories into concrete ones and can be analyzed in more detail so that this method can improve cognitive, psychomotor, and affective skills. Practical activities in schools currently still use large amounts of chemicals. The resulting waste is only thrown in the trash or the drain. Disposal of large amounts of chemical waste will affect the surrounding environment. Based on this background, the researcher aims to develop a small-scale practical kit and flipbook for instructions on practical acid and base solutions. This type of research is development research (R&D) and uses the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Material and language experts and media experts validate products. Product trials were carried out at SMAN 15 Tangerang Regency. The results of the validation of the small-scale practicum kit and flipbook practicum instructions were material 87% (very feasible), language 80% (feasible), and media 84% (very feasible). The product trial results stated that the small-scale practical kit and practical flipbook instructions were suitable for use in the learning process.

Keywords: Acids and bases; Flipbook; Practical kit; Practical instructions; Small-scale Chemistry

Introduction

Practicum is an essential part of learning that enables students to test and implement theory in real life. Learning in the laboratory provides practical learning opportunities for building students' knowledge (Akmalia et al., 2018; Bretz, 2019; Hidayah et al., 2022). Learning with practical methods can explain abstract theories into concrete ones and can be analyzed in more detail so that this method can improve cognitive, psychomotor, and affective skills and knowledge (Groos et al., 2021; Harefa & Fransisca Dewi Silalahi, 2020; Harefa & Suyanti, 2019). Students also require the use of practical modules packaged in e-module form. Using practicum e-modules influences learning outcomes and motivation (Godínez Castellanos et al., 2021; Kwarteng et al., 2023; Susanti et al., 2022).

Practical activities in schools currently use tools and chemicals on a large scale. Meanwhile, there is no place to dispose of chemical waste at school. Practical waste is only disposed of in rubbish bins or water drains. Large amounts of chemical waste will cause environmental pollution (Kwarteng et al., 2023). School practical activities should be carried out by applying the green concept of chemistry. Green chemistry is an environmentally friendly chemical that minimizes environmental pollution (Ahluwalia, 2009; Tatsiana Savitskaya, 2021; Warner et al., 2004). According to Anastas, the concept of green chemistry is closely related to its application in industry and adheres to 12 principles, namely (1) Prevention or utilization of waste; (2) Economic atoms; (3) Synthesis with harmless chemicals; (4) Produce safe chemicals; (5) Use of non-hazardous solvents; (6) Design for energy efficiency; (7) Use of renewable materials; (8) Reduction of derivative compounds; (9) Use of catalysts; (10) Design for decomposition; (11) Direct analysis for pollution prevention; (12) Safer processes and use of materials

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(Ahluwalia, 2009; Tatsiana Savitskaya, 2021; Warner et al., 2004).

Practical activities at school can be carried out using the green principles of chemistry by reducing the volume and mass of chemicals and replacing chemicals with natural ingredients or other safer ingredients. Small-scale chemistry (SSC) is a technique that can be carried out in green practicum activities chemistry (Ogunleye & Ogunleye, 2016). Small-scale chemistry (SSC) is an experimental technique carried out using small amounts of reagents or chemicals (Eggen & Kvittingen, 2004; Hanson, 2014; Mardhiya & Laila, 2022; Ogunleye & Ogunleye, 2016). Small-scale chemistry (SSC) can be used as a solution to overcome practical activities at school. Simple equipment and materials from the environment can be developed into efficient, practical kits for practicums (Mammino & Apotheker, 2021).

A small-scale practical kit is a set of tools designed in a smaller size. This kit aims to reduce the amount of chemicals used. The advantages of using a small-scale practical kit include (1) fewer materials are used compared to the macro scale; (2) toxic fumes are almost non-existent and minimize the waste produced; (3) less time required; (4) fewer costs used (5) less storage space because tools and materials are stored in boxes; (6) students become accustomed to saving and minimizing the use of practical materials (NCERT, 2018; G. Tesfamariam et al., 2014; G. M. Tesfamariam et al., 2017). Several studies explain that small-scale practical kits can improve understanding of chemical concepts and learning achievement (Kyung, 2014; G. M. Tesfamariam et al., 2017; Tole et al., 2019).

Practical instructions are needed when using the small-scale practical kit. In this digital era, most students already have handphones connected to the internet. These tools can be utilized in the learning process. Mobile phones can be used to access practical e-books. Flipbook is an e-book that can be created using the professional Flip pdf application. The appearance of this flipbook is attractive because of its pop-up shape, sound effects, and display, such as opening the pages of a printed book. This flipbook can add videos, hyperlinks, and backgrounds (Fujita et al., 2012; Haryanto et al., 2020; Lakapu et al., 2023).

Class XI students studied acids and bases at the beginning of semester 2. The chemical properties of acids and bases are often encountered in everyday life, so it is crucial to study them. Apart from that, acid-base material is related to the following material, namely hydrolysis and buffers (Irawati, 2019).

Based on this background, the researchers developed a small-scale practical kit and a flipbook for practical instructions on acids and bases. This product is hoped to reduce practical waste and become an attractive alternative learning media for students.

Method

This research is a research and development (R&D) using the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model development method (Branch, 2010). This study aims to develop a small-scale kit and flipbook for practical instructions on acid base solution material. The product is developed according to the needs of teachers and students. Development begins with making an experimental design, conducting laboratory trials, and ordering and modifying equipment. The product is validated by material language experts and media experts. After the product is declared valid, a trial is carried out. The trial stage was carried out at SMAN 15 Tangerang Regency. The results of the validation questionnaire analysis are in the form of a percentage of feasibility obtained based on a Likert scale. The practical media kit and flipbook are declared feasible if the results of the media validation value give a percentage of ≥ 61%. Implementation is carried out for small and large group tests, and the data obtained is processed to determine the feasibility of the kit and flipbook. Analysis of teacher and student response sheets produces a percentage of feasibility obtained based on the calculation of the Guttman scale. The practical media kit and flipbook are declared feasible if the student response assessment gives a percentage of ≥ 61%. The evaluation was conducted during the development process of the practical kits and flipbooks based on input from validators, teachers, and student assessments.

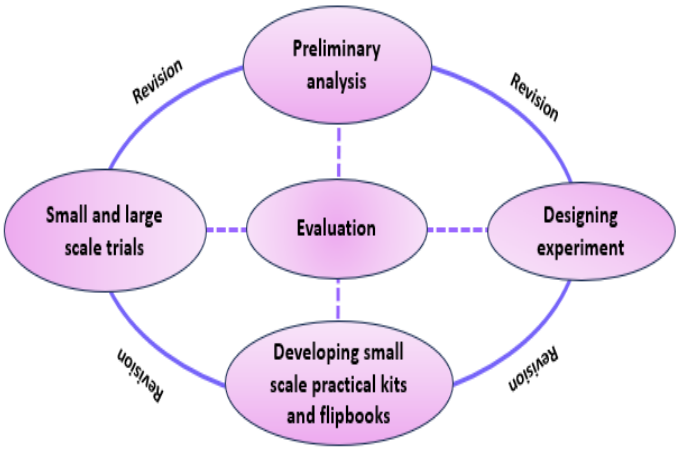


Figure 1. ADDIE (Analyze, Design, Development, Implementation, Evaluation) Model

Result and Discussion

This research aims to develop a small-scale practical kit and flipbook for practical instructions on acids and bases. This development was carried out based on current problems in several schools: the unavailability of laboratories and practical waste

processing. Chemical practicum activities in schools are currently carried out using large-scale (macro) tools and materials, while there is no particular place for the disposal or processing of chemical waste. Tools, materials, and practical instructions based on green chemistry are needed to reduce the amount of chemical waste in schools. The small-scale practical kit is one of the concepts that promote green chemistry (Ahluwalia, 2009; Tatsiana Savitskaya, 2021; Warner et al., 2004). The use of small-scale chemistry can realize several green chemistry concepts, including (1) prevention/utilization of waste/zero waste; (2) produce safe chemicals; (3) use of non-hazardous solvents; (4) direct analysis of police deterrence; (5) Safer processes and use of materials (Tantayanon, 2021).

This R&D project utilized the ADDIE model (Branch, 2009; Mesra, 2023). , chosen for its suitability for developing practical tools and books. Each stage allows for revisions and evaluations, facilitating the creation of practical tools. If the design proves inadequate, it can be promptly revised and evaluated (Mesra, 2023; Winaryati, 2021). The stages of this research can be explained as follows:

Analysis

At this stage, the need for practical kits in schools is determined. This analysis was carried out by filling out a questionnaire. A questionnaire sheet was made using Google Forms and distributed to 2 teachers and 60 students in class XII Science at SMAN 15 Tangerang Regency.

The results of the preliminary analysis state that practicum activities use tools and materials on a macro scale. The school still needs to get a laboratory or practical waste processing. Practical waste is disposed of in the trash or the water drain. Teachers and students stated that they wanted to try practicum with small-scale kits. Students already have handphones connected to the internet. Students and teachers expressed interest in trying to use flipbook practical instructions.

Design

This stage involves designing a small-scale practical kit, which includes designing small-scale practical equipment, designing small-scale practical instructions, collecting acid-base experiment references, determining the volume of small-scale experiments carried out by testing in the laboratory, and creating a flipbook design practical instruction. The design of the small-scale practical kit can be seen in Figure 2. The design of the flipbook for practical instructions can be seen in Figure 3.

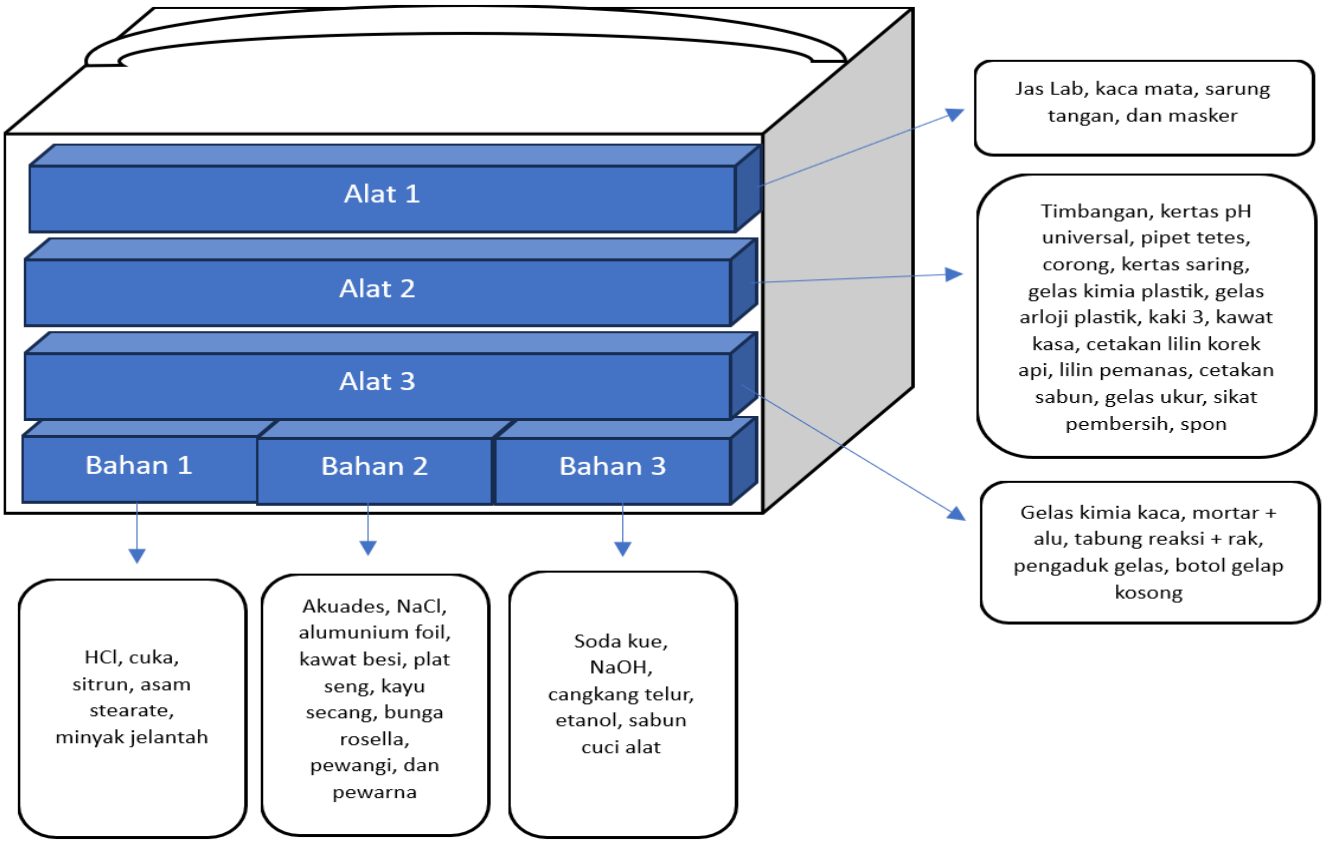


Figure 2. Small-scale practical kit design

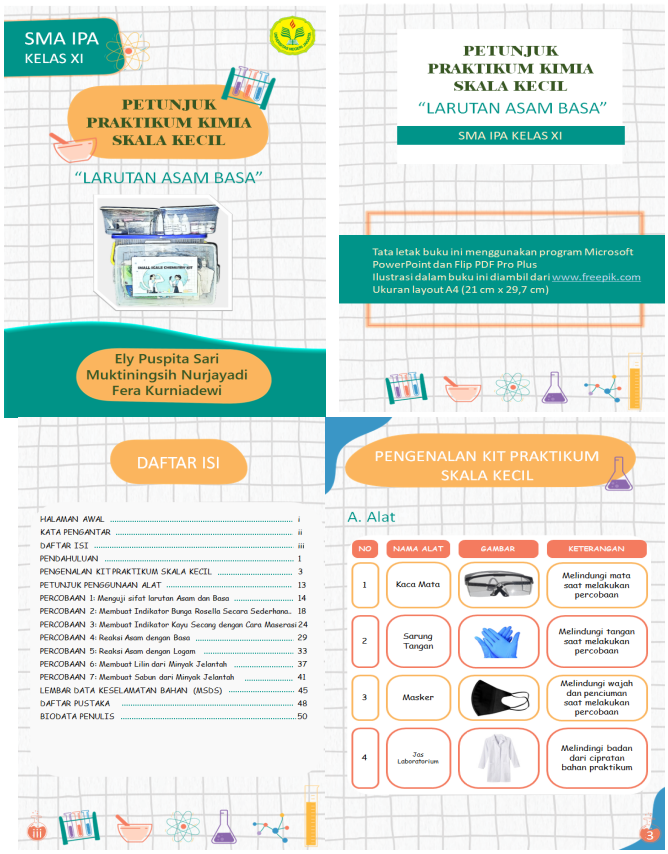


Figure 3. Practical instructions for flipbook design

Development

Development executes the designs. The kits and flipbooks developed are then tested by material, language, and media experts. This stage is essential to ensure that the product meets feasibility and needs.

At this stage, the instrument used is a questionnaire sheet for validation of material and language experts. This instrument determines the feasibility of the kit and flipbook developed in terms of the material and language used. The results of material validation and media experts can be displayed in Table 1.

Table 1 . Validation results

Expert	Aspect	%	Category
Material and Language	Relationship to material	87-93%	Very worthy
	Benefits for understanding concepts	92-96%	Very worthy
	Benefits to skills	90-93%	Very worthy
	Flipbook quality (language)	73-80%	Worthy
Media	Tool quality	71-89%	Worthy-Very worthy
	Material quality	75-85%	Worthy-Very worthy
	Tool efficiency	80-90%	Worthy-Very worthy
	Flipbook quality	80-83%	Worthy-Very worthy

Based on the validation results, a graph of the percentage quality of material, language, and media can be displayed in Figure 3. The percentage of material is 87% (very adequate), language 80% (adequate), and media 84% (very adequate). Some input from validators includes: (1) improve the writing on the flipbook; (2) improve the writing of tools and materials in the flipbook; (3) pay attention to the consistency of the words used (beaker); (4) repair the storage box; (5) group materials according to their properties (acid/base/neutral). The teacher's assessment can be shown in Table 2.

Table 2. Teacher assessment results

Aspect	Percentage	Category
Relationship to material	100	Very worthy
Flipbook quality	75-80	Worthy-Very worthy
Tool quality	86-100	Worthy-Very worthy
Material quality	67-100	Worthy-Very worthy
Tool efficiency	100	Very worthy
Benefits for understanding concepts	80-100	Worthy-Very worthy
Benefits to skills	83-100	Worthy-Very worthy

The small-scale trial stage involved one teacher and ten students of class XII Science at SMAN 15 Tangerang Regency. The extensive group test involved 60 class XII students at SMAN 15 Tangerang Regency. The results of the small and large group tests can be shown in Table 3.

Figure 4 shows the small-scale practical kit. Figure 4 shows the flipbook of practical instructions accessed using a handphone. Details of the small-scale practical can be seen in Table 4.

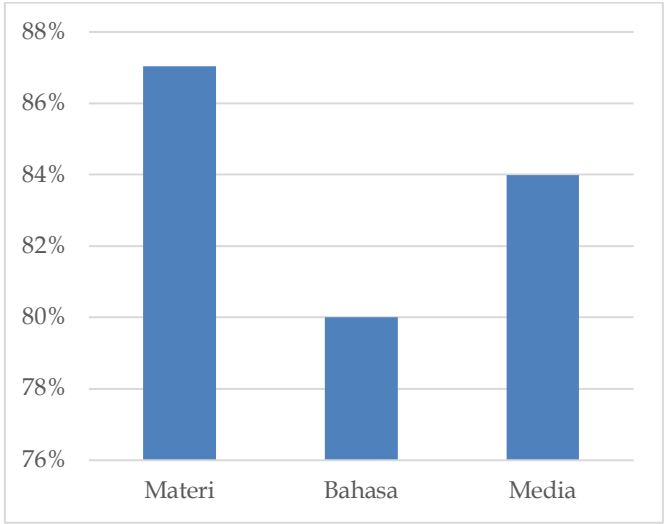
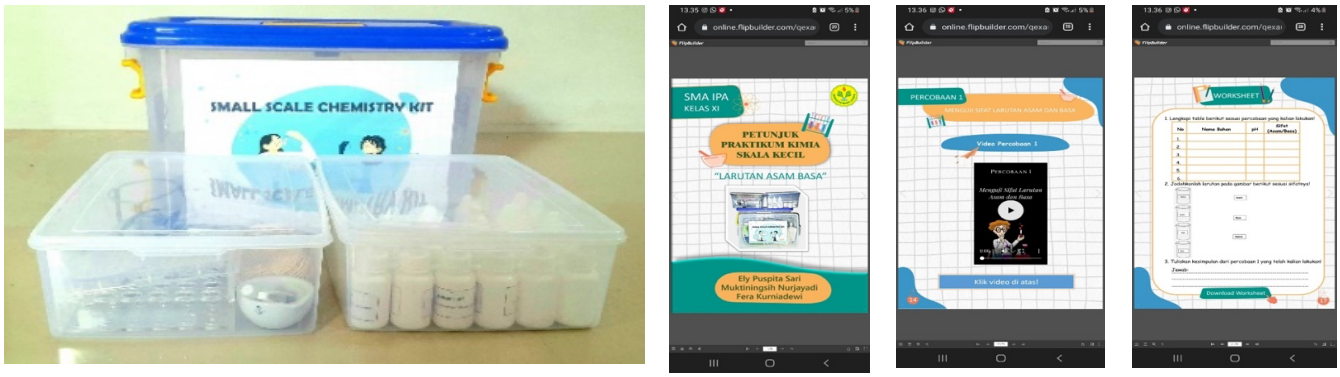


Figure 4. Graph of percentage validation of material, language, and media



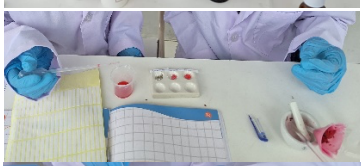
(a) (b)

Figure 5. (a) Small-scale practical kit; (b) practical instruction flipbook

Table 3. Results of small-scale and large-scale tests

Aspect	% (small scale)	Category	% (large scale)	Category
Relationship to material	100%	Very worthy	100%	Very worthy
Flipbook quality	100%	Very worthy	100%	Very worthy
Tool quality	60-100%	Decent enough-Very worthy	80-100%	Worthy-Very worthy
Material quality	67-100%	Worthy-Very worthy	67-100%	Worthy-Very worthy
Tool efficiency	100%	Very worthy	100%	Very worthy
Benefits for understanding concepts	80-100%	Worthy-Very worthy	80-100%	Worthy-Very worthy
Benefits to skills	83-100%	Worthy-Very worthy	83-100%	Very worthy

Table 4. Small-scale practicum

Test title	Image of practical activities	Tool	Material
Test the properties of acid and base solutions		Drop plate, dropper pipette, universal indicator, label paper	HCl, NaOH, vinegar, citrus, NaCl, baking powder
Make a simple rosella flower indicator		Stirrer, watch glass, drop plate, mortar + pestle, beaker, measuring cup, scale. Funnel, filter paper, label paper	Rosella buds, distilled water, citrus, baking soda, table salt
Making sappan wood indicators by maceration		Empty dark bottle, stirrer, funnel, watch glass filter paper, dropper plate, dropper pipette, weighing scale, label paper	Secang wood, ethanol, distilled water, citrus, baking soda, table salt
Reaction of acids with bases		Test tube + rack, tweezers, label paper	Egg shells, baking soda, citrus, vinegar, HCl
Acid reactions with metals		Test tube + rack, label paper, dropper pipette	Aluminum foil, iron wire, zinc wire, HCl

Test title	Image of practical activities	Tool	Material
Test the properties of acid and base solutions		Drop plate, dropper pipette, universal indicator, label paper	HCl, NaOH, vinegar, citrus, NaCl, baking powder
Make candles from used cooking oil		Glass beaker, stirrer, mold + candle wick, 3 legs + wire mesh, candle, matches	Used cooking oil, stearic acid, candle wick, fragrance, powder dye
Make soap from used cooking oil		Beakers, stirrers, scales, watch glasses, soap molds, dropper pipettes, measuring cups	Used cooking oil, NaOH powder, distilled water, coloring, fragrance

The small-scale practical activity received a positive response from teachers and students. This response is in line with the results of previous research that small-scale chemistry practicum activities can support the application of green chemistry and can be used in chemistry practicum activities (Harta et al., 2020; Hidayah et al., 2022; Mardhiya & Laila, 2022). Using practical instructions as a flipbook can help students understand the content of practical activities. This result is because, in the flipbook, there is a video of a practical explanation.

I*mplementation*

Implementation was carried out at SMAN 15 Tangerang Regency. Small-scale practical kits and flipbooks are used in the learning process in class XI Science.

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Evaluation

The evaluation was conducted formatively and summatively (Branch, 2010; Mesra, 2023). The parts that underwent subsequent evaluation and revision based on validation and trials were enlarging the storage box to prevent stacking of tools. Separating and providing foam mats for tools that are prone to breakage. Adjusting the height threefold. Sorting materials by type (acid, base, neutral). Fixing the font size in the flipbook text. Addressing accessibility issues with one video. Ensuring all tools are listed in the flipbook. A small-scale practical kit is a set of useful tools designed to be small in size (Ref: small-scale kit). In this study, lab tools have been developed that are designed similarly to regular lab tools, but only in smaller sizes.

The small-scale lab kit was developed to create an alternative environmentally friendly lab tool because it produces little chemical waste. Minimizing the formation of chemical waste is one aspect of green chemistry (Eva Fadillah, 2022; Harta et al., 2020). The small-scale lab kit has also been proven to save the chemicals used. Storage is easier because it is only small in size. This tool can be used independently at school or home because it is easy to carry. This tool is equipped with lab instructions in the form of a flipbook. Flipbook is one of the interactive e-books (Fujita et al., 2012). The use of flipbooks makes it easier for students to use lab tools. The advantages of flipbooks are that they are interactive, easy to access, easy to share, cost-effective, environmentally friendly, attractive, support distance learning, easy to carry, and can be accessed online and offline (Lakapu et al., 2023). In the flipbook, there is a video guide to the experiment which aims to make it easier for students to understand the lab activities. Using videos in the lab instructions has been proven to improve students' understanding (Aini et al., 2023; Baitty & Sukmawati, 2022). Combining the small-scale lab kit and the lab instruction flipbook will provide an interesting experience for students. An interesting lab experience will make students more motivated to learn chemistry. This is in line with several previous studies which stated that small-scale chemistry can improve learning motivation, learning outcomes and science process skills (Aini et al., 2023; Imaduddin et al., 2020; G. M. Tesfamariam et al., 2017). The use of flipbooks can also increase motivation and learning outcomes (Juliani & Ibrahim, 2023). In further research, the implementation of the small-scale lab kit and the lab instruction flipbook will be carried out in classroom learning.

Conclusion

In conclusion, the preliminary analysis conducted at SMAN 15 Tangerang Regency and SMAN 31 Tangerang Regency indicates the current reliance on macro tools for practicum activities, with a pressing need for laboratories and waste management facilities. Introducing practical activities rooted in green chemistry is imperative for enhancing safety both for students and

the environment. Adopting the small-scale chemistry concept aligns with the principles of green chemistry, effectively minimizing chemical usage and waste production. Furthermore, providing practical instructions in flipbook format significantly aids in implementing these activities. The inclusion of instructional videos further enhances student comprehension of the practicum steps. The resultant products of this research, namely small-scale practical kits and flipbooks for acid-base instructions, offer tangible solutions to these challenges. Utilizing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), this research engaged material, language, and media experts for product validation. The validation process yielded promising results, with the small-scale practicum kit and flipbook instructions deemed highly feasible by stakeholders. Subsequent product trials at SMAN 15 Tangerang Regency affirmed the suitability of these resources for effective learning environments.

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Author Contributions
This research article was collaboratively authored by Ely Puspita Sari, first author, Fera Kurniadewi, second author, and Muktiningsih Nurjayadi, corresponding author. The authors contributed to creating small-scale practical tools and flipbook practical instructions, conducting research, analyzing data, and writing the article. All authors thoroughly reviewed the findings and approved the final manuscript.

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Conflicts of Interest
No conflict interest.

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