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SuCA: Free Android Application to Calculate and Provide Chemical Preparation Procedures

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Abstract

The chemistry laboratory plays a vital role in chemistry education by facilitating hands-on learning. Unfortunately, teachers often face limitations and difficulties during the preparation of chemical reagents. Therefore, this research aimed to develop the Solution Calculator Application (SuCA) as an open-access application designed to aid chemistry teachers in preparing chemical solutions for lab experiments. Employing a Research and Development (R&D) method, the study involved 113 subjects, including chemistry teachers, lab technicians, and pre-service student, across five assessment aspects: content, applicability, design, technical, and usability. Data were collected and then analyzed using descriptive statistical analysis. SuCA allows teacher calculate required amounts and provides preparation guidance, easing the burden on teachers, especially in Indonesian schools where lab technicians are often absent. The app features seven menus, including instructions, solution preparation from solids and liquids, dilution calculator, concentration conversion, preparing metals in ppm, and application information. Users can also modify the existing database. The app scored an average of 79.70% of excellence performance. These findings imply that SuCA serves as a practical, accessible tool to streamline laboratory preparation.

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Introduction

Engaging in laboratory work is essential for advancing chemistry as it enables students to develop crucial skills in synthesis, analysis, and instrumentation (Bretz, 2019). Laboratory work is indispensable in fostering a comprehensive understanding of chemistry, nurturing scientific skills, and fostering a lifelong passion for the subject (Ramulumo & Mokiwa, 2023; Sopian & Zamhari, 2025). Additionally, conducting experiments in the lab reinforces students' understanding of chemistry by validating concepts learned in the classroom and elevating students' academic performance in the field of chemistry (Kolil & Achuthan, 2024). To maximize the benefits, starting laboratory work early, both in secondary schools and universities is crucial. By doing so, students can fully leverage the advantages offered by practical hands-on experiences (Rowe, Koban, Davidoff, & Thompson, 2018).

In Indonesia, teachers often take on the additional role of technicians due to the scarcity of chemical laboratory technician in schools (Faisal & Martin, 2019). Unfortunately, schools lack dedicated chemistry lab technicians who can assist teachers with equipment and chemical preparations (Mastura, Mauliza, & Nurhafidhah, 2017). As a result, teachers are burdened with the responsibility of preparing lab tools and materials themselves. These skills are typically acquired during their undergraduate education or through relevant training programs (Ridasta, 2020). However, this puts a heavy workload on teachers as they not only have the responsibility of teaching but also need to prepare for chemistry experiments at school (Faisal & Martin, 2019).

Furthermore, teachers in Indonesia face an imbalanced teacher-to-student ratio, which results in an overwhelming teaching burden (Kusanagi, 2022). Despite this challenge, teachers must meticulously prepare their lessons to effectively convey chemical information (Pradnyantika, Sudiana, & Wiratin, 2018). The burden and responsibility mean that chemistry teachers have limited time for adequate preparation and often struggle to carry out practical experiments in the school setting (Kusanagi, 2022). It is essential to address these challenges and provide support to teachers to ensure the successful implementation of practical work in the laboratory (Yalcin-Celik, 2017).

Implementing practical experiments in the laboratory comes with financial obstacles. The high costs associated with conducting practical work often hinder its execution (Mehta, 2021). Schools and institutions face financial constraints due to the expenses related to materials, equipment, and chemicals required for practical work (Hernández-de-Menéndez, Guevara, & Morales-Menendez, 2019). To overcome these financial challenges, optimizing the use of chemicals during lab work is crucial, ensuring efficient calculations regarding the required materials (EPA, 2023). Proper chemical handling will not only reduce costs but also positively impact the environment by minimizing waste production and reducing the negative effects of working with hazardous materials (Hamidah, Zamhari, & Eilks, 2018).

Accurate calculations play a vital role in the successful execution of lab work. Determining the concentration of solutions requires precise calculations and knowledge of various factors (Konieczka & Namiesnik, 2018). For example, when working with solid substances and using molar units (M), information about the solute's relative mass is necessary (Harvey, 2000). However, searching for this information can be time-consuming. Similarly, determining a concentrated solution's concentration requires knowledge of relative mass and density (Harvey, 2000). Gathering these initial details can significantly prolong the solution calculation process. Streamlining the calculation process and providing easy access to necessary information would greatly enhance the efficiency of lab work (Moriwaki, Tian, Kawashita, & Takagi, 2018).

Steps can be taken to simplify the preparation processes to address the challenges faced in practical work. One approach is to create a guidebook that provides instructions and material preparation guidelines (Nainggolan, Pinem, & Hutabarat, 2018). Developing a guideline book that outlines the preparation and calculation of chemicals can also be beneficial (Harahap, Sari, Pane, & Nurain, 2019). However, these methods have limitations, such as difficulties in updating calculations for new chemicals and the need for different calculations for different concentrations. Therefore, a technological solution in the form of an application is necessary to streamline the process.

In Indonesia, the use of smartphones is prevalent, with a significant percentage of internet users accessing the internet through smartphones (Cakranegara, Yusuf, & Mayasari, 2022). Leveraging the popularity and capabilities of smartphones, an application can be developed to simplify the preparation processes for chemistry experiments (Ardianti, Rondli, Wanabuliandari, & Gunarhadi, 2025; Zamhari, Ridzaniyanto, & Kangkamano, 2021). However, access to good quality internet in Indonesia is still uneven. Some areas still face difficulties in accessing the internet. Therefore, there is a need for an application that can be used for free and does not require internet access during its operation (Ariansyah et al., 2023). The Solution Calculator Application (SuCA) is an open-access application designed to assist teachers in materials preparation, including offline calculations and step-by-step instructions. SuCA can be accessed for free on http://bit.ly/4p4uErB. By utilizing SuCA, teachers and lab technicians can overcome the challenges of time-consuming material preparation and enhance the effectiveness of chemical usage. The application's expandable database ensures adaptability to new chemicals, and its compatibility with mobile phones allows for convenient usage anytime and anywhere. SuCA serves as a valuable tool to ensure the continuity of practical work and leverage technological innovations in education.

The study presents a novel chemical calculator product and its comprehensive application to chemistry teachers, lab technicians, and pre-service student. By offering a free and offline-functional platform, SuCA specifically supports chemistry educators, especially in remote regions who face severe internet constraints. This innovation establishes a vital baseline and a catalyst for future application developments aimed at optimizing laboratory preparation processes

Method

This study adapted the Research and Development (R&D) model proposed by Borg and Gall, which originally comprises ten sequential stages (Assirri et al., 2026): (1) Research and Information Collecting, (2) Planning, (3) Develop Preliminary Form of Product, (4) Preliminary Field Testing, (5) Main Product Revision, (6) Main Field Testing, (7) Operational Product Revision, (8) Operational Field Testing, (9) Final Product Revision, and (10) Dissemination and Implementation. To ensure a continuous and streamlined discussion, these ten stages were synthesized into four simplified phases. First, Research and Information Collecting and Planning were consolidated into the Analysis phase. Second, Develop Preliminary Form of Product, Preliminary Field Testing, and Main Product Revision were categorized under the Product Development phase. Third, the subsequent steps, Main Field Testing, Operational Product Revision, Operational Field Testing, and Final Product Revision, were adapted into a more streamlined, small-scale Large Field-Testing phase. Unlike traditional educational products, this application functions as a laboratory utility tool rather than instructional material; thus, comparative testing was omitted, and evaluations were conducted directly by chemistry teachers, laboratory technicians, and pre-service chemistry students. Finally, the Dissemination and Implementation phase was realized through the publication of the research findings.

The product developed in this study is the Solution Calculator Application, an open-access application designed to aid chemistry teachers in preparing chemical solutions for lab experiments. Development of the product and assessed followed these stages,

A preliminary needs analysis was conducted prior to the development of SuCA. The purpose was to ensure the developed produc would align with the requirements for teacher and lab technician. This step was carried out using interviews. The interviews involved two chemistry teachers. The interview topic focused on the problems teachers face in conducting chemistry practicums at the school. These interviews aimed to identify the constraints encountered during the implementation of these practical sessions. Then, The results of the interview were reinforced by findings from a literature study.

The next phase is product development, this is the stage for designing and preparing the product development. This stage covered planning and developing the product. The development employed *CorelDRAW X7* to design and Web Kodular to develop the application. The product development phase was specifically designed to address practical field needs by integrating essential features for chemical reagent preparation and concentration conversion, such as solution from solid, solution from liquid, dilution, concentration convertion, and metal preparation in ppm. Then, the product was ensured to perform in content, applicability, design, technical, and usability aspects.

Media and subject matter experts validated the product, then proceeded to the initial field trial stage. This preliminary trial aims to determine the quality of the developed product with a small group of users. At this stage, the product draft was evaluated by five users, all of whom were chemistry teachers. The collected assessment data was then analyzed using predetermined techniques to ascertain the product's quality. Feedback and suggestions from these users were then used as the basis for revision before moving on to a larger-field testing. This phase utilized assessment and validation instruments that were pre-validated by an instrument expert.

Large-scale field testing is conducted to determine the product's impact on a wider scale. This trial involves a large number of participants, including chemistry teachers, lab technicians, and prospective chemistry teachers. The data were collected using a 5-point Likert scale instrument, ranging from 'Very Good' (5) to 'Very Poor' (1). To interpret the participants' responses, the gathered quantitative data were analyzed using descriptive statistics. This analysis involved calculating the percentage of excellence performance and the average scores for each evaluation aspect. The descriptive results were then categorized based on predetermined interval criteria to determine the application's overall quality and effectiveness.

Results and Discussion

Analysis

This activity was conducted by interviewing two chemistry teachers. Based on the interview results, several obstacles were identified. One of the most significant challenges in implementing chemistry labs is time availability. The limited time allocated for chemistry lessons often disrupts lab activities requiring extensive preparation. Currently, the teacher must create the lab instructions along with a list of needed tools and materials, which is then handed over to the lab assistant for preparation. Although the school has a lab technician, it is not impossible for the teacher to have to prepare the lab materials themselves if the assistant is unable to be present. This type of situation significantly hinders chemistry lab activities because it increases the teacher's workload, and lab preparation—especially preparing solutions—cannot be done quickly.

This obstacle indicates the need for a tool to assist in preparing chemistry labs. Such a tool could be a calculator that can quickly, accurately, and effortlessly determine solution concentrations. This would make the time required for teachers to prepare for labs faster and more efficient. As a result, teachers would no longer face obstacles in implementing chemistry labs due to their limited time. These interview findings are corroborated by a literature review, which reveals a significant issue in many schools: the absence of a dedicated lab assistant. This shortage forces chemistry teachers to perform dual roles as instructors and lab technicians (Kusanagi, 2022). The situation is problematic because practical lab work is integral to the study of chemistry, a subject that emphasizes understanding processes and verifying theories through experimentation, not just learning outcomes (Yalcin-Celik, 2017). Hernández-de-Menéndez et al. (2019) confirms that practical activities positively impact student learning outcomes, making lab sessions essential to a complete chemistry education.

Product Development and Overview of the field covered by the application

One of the main advantages of SuCA's design is its stand-alone character, which enables offline usage. This feature allows users to utilize the application anywhere, even in areas of Indonesia with lack of internet access. The inclusion of a comprehensive database enables users to modify and tailor the available information to suit the materials present in their laboratory. Furthermore, SuCA not only offers calculation services for chemical preparations but also provides guidance on the various stages of manufacturing. This functionality allows users to efficiently, precisely, and accurately prepare chemicals. The swift calculations offered by the application save valuable time for teachers and lab technicians in the Chemistry Lab. Additionally, the accuracy of the calculations helps minimize the usage of chemicals, leading to a reduction in chemical waste. This aspect aligns with the principles of green chemistry while also reducing the costs associated with purchasing chemicals.

Figure 1 shows the initial interface of the application. The application is presented in the Indonesian language, as it is specifically designed for teachers, lab technicians, and researchers in Indonesia. The initial display comprises several primary menus, including instructions for usage, solution from solid, Solution from Solution, dilution, concentration conversion, metal in ppm preparation, and information about the application.

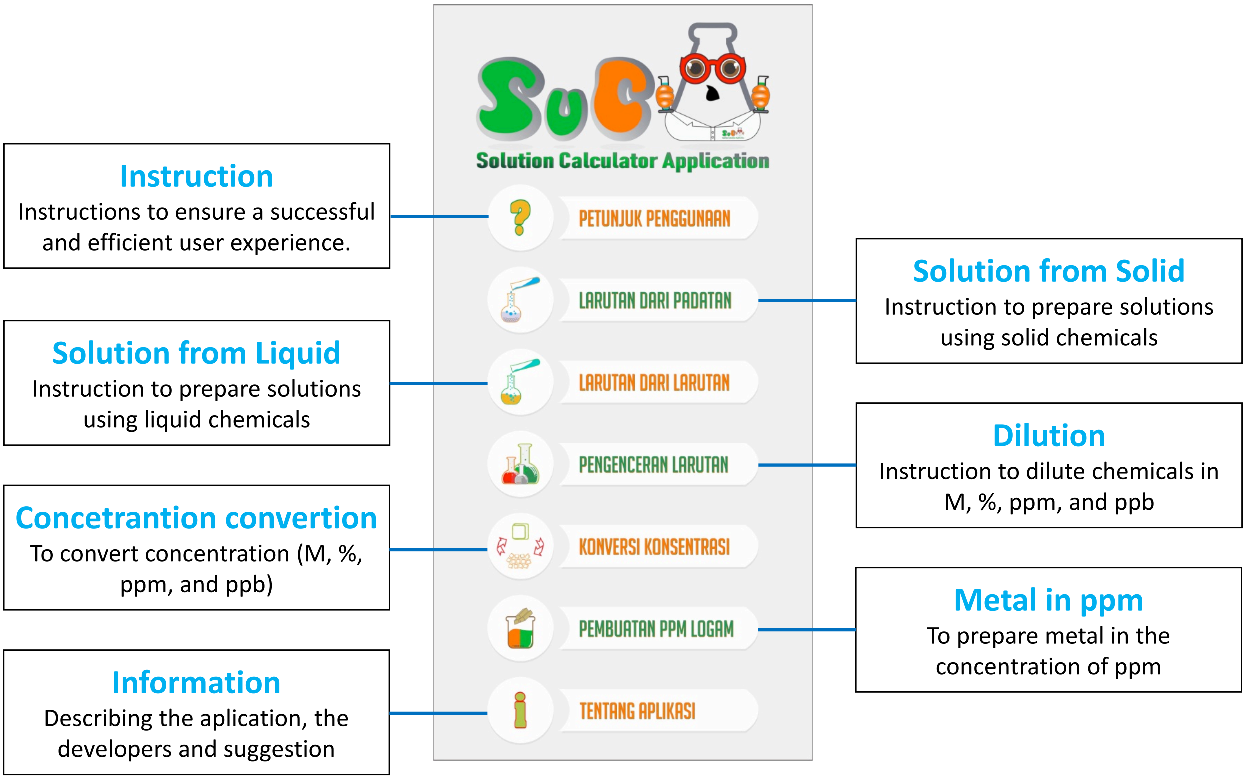

Figure 1. The Initial Interface of Solution Calculator Application (SuCA)

1. Instruction

Understanding the instructions for using an Android application is of significant importance in achieving a successful and efficient user experience (Chien, Lin, & Yu, 2014). Familiarizing with the instructions will help the user fully utilize the comprehensive features provided by the application (Moumane, Idri, & Abran, 2016). By knowing how to navigate various functions and options, the user will be able to optimize the usage experience and derive maximum benefits from the available features. The usage instructions assist in saving time and effort that would otherwise be spent on figuring out how to use the application on their own (Hendikawati, Zuhair Zahid, & Arifudin, 2019). By following the provided instructions, the user will swiftly grasp the functionality of the application and start using it without difficulty (Hoehle & Venkatesh, 2015).

The instruction menu includes instructions for operating and utilizing each menu within the application, accompanied by the main menu buttons. The placement of the button at the top facilitates user learning of the application and quickly access the information (Figure 1). This allows users to easily access and familiarize themselves with the functions and operations of each menu (Salman, Ahmad, & Sulaiman, 2018). The user guide menu serves as a helpful reference, providing clear instructions on navigating and utilizing the various features of the application.

2. Solution from Solid

The section for preparing solutions from solids assists users in calculating and understanding the process of creating solutions from solid chemicals, such as NaOH, NaCl, $CaCl_2$, Na_2SO_4, and other solid chemicals. In this section, users can select from the available materials in the database or add new ones to the database called "add solid chemicals (*Tambah Padatan*) sub-menu" (Figure 2.A). This sub-menu facilitates the convenient addition of solid data to the application, providing users with a comprehensive database of solid chemicals (Figure 2.B). The inclusion of various features such as data validation and selection options enhances the usability and functionality of the application, ensuring a smooth user experience.

Once a material is selected, users can choose the desired concentration and final volume, and then proceed by tapping the "Create (*Buat*)" button. Subsequently, the steps to follow will appear in the "Summary (*Kesimpulan*)" section, outlining what needs to be done. Figure 2.C shows the preparation of 2 M NaOH. Selecting the creation of a 2 M NaOH solution with a volume of 250 mL will generate the step of dissolving 20 grams of NaOH solid in a 250 mL volumetric flask and filling it to the mark with water. This feature provides users with a convenient and efficient method to calculate and execute the preparation of solutions from solid chemicals. By presenting clear instructions and allowing customization of concentrations and volumes, the application streamlines the process and enhances user experience.

3. Solution from Liquid

The preparation of solutions from solutions involves creating chemical solutions from liquid chemicals, which differs from the preparation of solutions from solids. In this section, users are not only required to input the molecular weight but also the density and concentration or percentage of the substance (Figure 2.D). Similar to other sections, users can also add data to the database (Figure 2.E). This is necessary because different manufacturers may have varying densities and concentrations for the same substance. The section for preparing solutions from solutions also includes the original manufacturer's name.

For instance, when preparing a 65% HNO_3 solution from Merck with MW of 63.01 g/mol, the corresponding density of 1.39 kg/L and a concentration of 65% will be provided (Figure 2.F). After determining the desired concentration and final volume, such as 2 M and 1000 mL, and clicking the "Create (*Buat*)" button, the concentration of the base substance, which is 14.338 M, will appear along with a summary of the preparation steps. Additionally, for acidic substances, there will be additional red-colored information stating that the solution is acidic and cautioning users to fill the volumetric flask with water first. This precaution is to prevent sudden temperature changes after adding the acid, which could lead to accidents in the laboratory. The instructions for the preparation also emphasize the importance of considering the exothermic and endothermic nature of the solution. This section provides users with comprehensive information to prepare solutions from liquid chemicals. The inclusion of additional details, such as manufacturer information, density, and warnings regarding the nature of the solution, ensures safe and accurate preparation while adhering to proper laboratory practices.

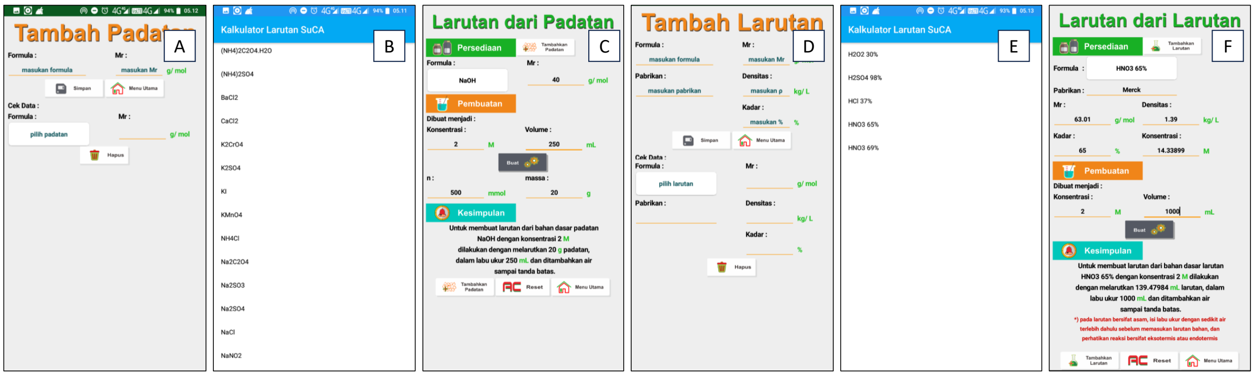

Figure 2. SuCA Application on Sub-Menu Of (A) Add Solid Chemicals Database, (B) Data Base of Solid Chemicals, (C) Solution Preparation from Solid, (D) Add Liquid Chemicals Database, (E) Data Base of Liquid Chemicals, and (F) Solution Preparation from Liquid.

4. Dilution

In the dilution of solutions section, several concentration options are available, including Molar, Percent, ppm (parts per million), and ppb (parts per billion) (Figure 3.A and B). Users can select their desired concentration, for example, Molar. After clicking the "Calculate (*Hitung*)" button, the required initial volume of the solution will be displayed. In the conclusion section, the dilution steps will be presented. For instance, if the initial solution has a molar concentration of 2 M, and the desired concentration and final volume are 0.1 M and 250 mL, respectively, the conclusion section will provide the following steps: to create a 0.1 M solution, dissolve 12.5 mL of the initial solution with a concentration of 2 M in a 250 mL volumetric flask and fill it up to the mark with water. The same process can be applied for ppm, ppb, and percent concentrations. This section allows users to easily calculate the dilution of solutions based on their preferred concentration. The step-by-step instructions provided in the conclusion ensure accurate and precise dilution, allowing users to achieve their desired concentration with ease.

5. Concentration convertion

The conversion of chemical solution concentrations is crucial for calculations involving solutions with different concentrations. In this section, there are several commonly used concentration units, namely M, %, ppm, and ppb (Figure 3.C). The conversion between these concentrations can be done by determining the known initial concentration and converting it to the other three concentrations by inputting the molecular weight and density values. If the substance is in solid form, the density value can be filled with the number 1.

For example, let's consider the conversion from percent to other units using the example of 65% HNO_3 with a molecular weight of 63.01 g/mol and a density of 1.39 kg/L. After clicking the conversion button, the application displays a concentration of 14.338 M. This confirms the conversion in the solution preparation section and shows that the calculated values are accurate. The other concentrations, in order, are shown as 903449.7599 ppm and 9.03 x 108 ppb. Another example is to convert 20,000 ppm of Cr with a molecular weight of 52 g/mol into other concentrations. After inputting the required data, the conversion yields 2.00%, 0.38462 M, and 20,000,000 ppb. This step simplifies the process for users when converting available concentration information into other concentration units.

6. Preparing ppm of metal

The preparation of ppm (parts per million) solutions from metals is widely used in the field of analytical chemistry. This sub-menu is possible to calculate and provide the steps of the preparation (Figure 3.D). Moreover, this additional menu can be utilized to create a parts per million (ppm) solution not only for different cations but also for anions. This feature expands the versatility of the menu beyond its primary function. In this section, users can utilize information from the existing database or add new information to the database. When adding information to the database, the metal formula, atomic weight of the metal, solid formula, and solid molecular weight are required (Figure 3.F). This is necessary because the amount of metal in different chemical substances can vary. For example, the amount of chromium (Cr) in K_2CrO_4 and $K_2Cr_2O_7$ will be different.

A practical example of its usage is when user wants to prepare a solution containing 20000 ppm of chromium (Cr) in a volume of 100 mL. The first step is to select the chromium (Cr) metal. After clicking on chromium (Cr), the atomic weight of chromium (Cr), which is 52 g/mol, will be displayed. The next step is to choose the chemical substance to be used, such as K_2CrO_4, which has a molecular weight of 194.19 g/mol. The following step is to enter the amount of chromium (Cr) in the molecule. Since the solid being used is K2CrO4, there is 1 chromium (Cr) atom in the molecule, and it is entered as n, with a value of 1. After determining the desired final concentration, let's say 20,000 ppm, the "Create (Buat)" button is clicked.

The final result or conclusion shows the steps that need to be followed. To prepare a solution from the solid K_2CrO_4 with a chromium (Cr) metal content of 20000 ppm, dissolve 7.46885 grams of the solid in a 100 mL volumetric flask and fill it up to the mark with water. This section provides users with a practical method for preparing ppm solutions from metals. By offering step-by-step instructions and allowing customization of the metal and solid information, users can accurately and efficiently create solutions with the desired metal concentration.

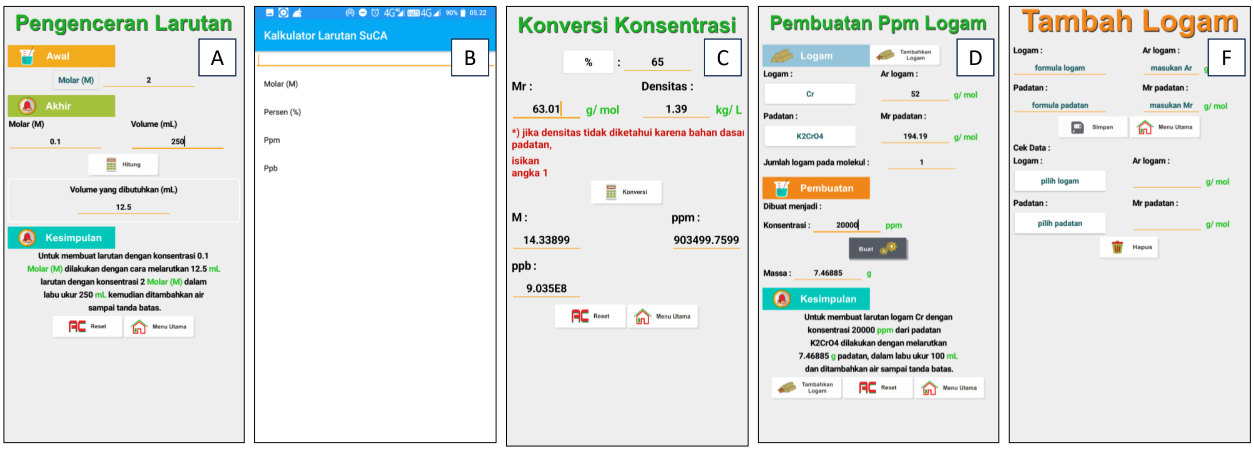

Figure 3. SuCA Application on The Sub-Menu of (A) Dilution, (B) Concentration Selection, (C) Concentration Convertion, (D)Metal Preparation in Ppm, (D) Additional Database of Metal.

7. Information

This section serves to provide users with details about the application and its creators. It establishes transparency and encourages feedback from users, as they are welcome to reach out with any suggestions or criticisms they may have. By including the developers' names and contact information, users can easily communicate their thoughts and contribute to the improvement of the application.

Preliminary Field Testing

The SuCA application, which has been developed, underwent initial testing on a limited scale to gather valuable suggestions and input before undergoing broader testing. This preliminary testing phase involved material, media experts, and five chemistry teachers (Table 1). The primary focus was to gather feedback, particularly regarding the content's accuracy and the application's effectiveness. Evaluating the accuracy of the content aimed to ensure that the calculations generated by SuCA align with the expected results in chemical laboratory calculations. Simultaneously, assessing the effectiveness of the application aimed to gather insights on the user-friendliness of the interface and overall usability of the media.

By conducting this initial limited testing, the developers sought to obtain valuable feedback from experts in the field, allowing for necessary adjustments and improvements. The input received from chemistry lecturers and teachers was particularly valuable in ensuring the correctness of the materials and enhancing the application's overall effectiveness as an educational tool. The focus on accuracy and effectiveness aimed to provide users with a reliable, precise, and user-friendly experience while utilizing SuCA for chemical calculations and preparation. The results of this limited test indicate that the product meets the criteria and is ready for a larger field testing.

Table 1. Quality Assessment Data for the SuCA by Material, Media Experts, and Five Chemistry Teachers.

Assessor	Apects	Percentage	Category
Material Expert	Content	75%	very good
	Efectivity	100%	very good
	Average	88%	very good
Media Expert	Applicability	100%	very good
	Design	81%	very good
	Technical	100%	very good
	average	95%	very good
Five Chemistry Teachers	Content	99%	very good
	Efectivity	90%	very good
	Applicability	100%	very good
	Design	80%	very good
	Technical	89%	very good
	Usability	80%	very good
	Average	90%	very good

Large Field Testing

An extensive testing was conducted involving 113 respondents, consisting of 50 chemistry teachers, 8 lab technicians, and 50 pre-service chemistry students. The testing covered five assessment aspects: content, applicability, design, technical, and usability, with a total of 32 indicators. The results of the test are presented in Figure 4 and summarized in Table 2. Table 2 shows that the product received excellent ratings ranging from 72.44% to 84.29%, good ratings ranging from 13.72% to 22.63%, and fair ratings ranging from 0.71% to 4.68%. Meanwhile, the SuCA application did not receive any negative feedback, as indicated by the low percentage of poor ratings, which only appeared in the applicability aspect and design aspect, with 0.13% and 0.25% respectively. There were no ratings of very poor for the developed product. These results indicate that the developed application is helpful for calculations and the preparation of chemical experiments or research in the laboratory.

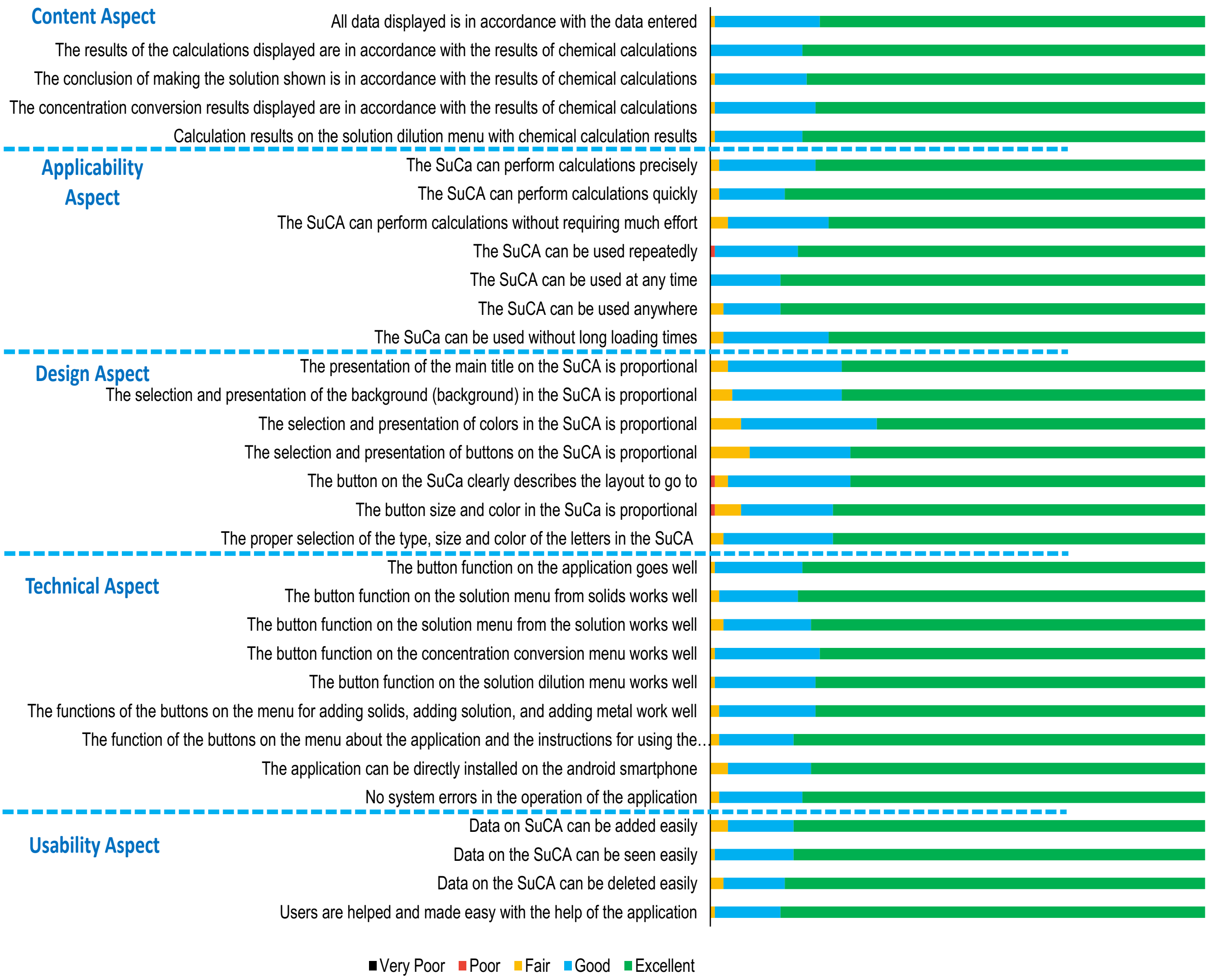

Figure 4. Product Assessment by 113 Respondents, Consisting of 50 Chemistry Teachers, 8 Lab Technicians, and 50 Pre-Service Chemistry Students in Indonesia

Table 2. Evaluation of The Product in The Aspect Of Content, Applicability, Design, Technical, and Usability

Aspect	Percentage (%)				
	Very Poor	Poor	Fair	Good	Excellent
Content Aspect	0,00	0,00	0,71	19,29	80,00
Applicability Aspect	0,00	0,13	1,77	16,69	81,42
Design Aspect	0,00	0,25	4,68	22,63	72,44
Technical Aspect	0,00	0,00	1,77	17,90	80,33
Usability Aspect	0,00	0,00	1,99	13,72	84,29
Average	0,00	0,08	2,18	18,04	79,70

Conclusion

The open-access and stand-alone SuCA offers a unique feature that helps users calculate and prepare chemical solutions in the laboratory. It is fulfilling the aim of the research to develop an accessible technological solution to assist chemistry educators in laboratory reagent preparation, overcoming the constraints of limited preparation time and the absence of laboratory technicians. This application provides an adaptive facility that allows users to add and delete their own database. Additionally, it can be used without an internet connection, making it accessible to users in Indonesia, where internet access may be limited. Testing of this application with chemistry teachers, lab technicians, and students has shown that it effectively assists users in calculating and preparing chemical substances. Ultimately, this study impacts chemical education by bridging the digital divide for rural schools, reducing the administrative and logistical burden on teachers, and serving as a foundational stepping stone for future, more advanced digital assistants in laboratory management.

Credit Authorship Contribution Statement

Muhammad Zamhari: Conceptualization, Methodology, Data Collection, Writing – original draft, Writing – review & editing. **Zainal Arif Subekti**: Software, Visualization, Data Collection, Project administration.

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