Development of an Android-Based Color Detector for Chemistry Experiment in the Classroom

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Abstract. This study aims to develop an android-based color sensor for chemistry practicum and demonstration in front of the class using colored chemicals. The materials used are cardboard boxes, laptops as light sources, test tubes and smartphones for testing the Lambert-Beer experiment and titration apparatus such as oxalic acid, NaOH, indicator, stative, clamps prepared for the acid base experiment. The relationship of concentration versus absorbance was observed. The results show that this application has a very high accuracy with a $r^2 = 0.999$. This application is highly recommended to be applied in school chemistry teaching and practicum and is very useful to help students with color vision limitations.

Keywords: colorimetry · color sensor · acid-base experiment · Lambert-Beer's experiment

1 Introduction

Chemistry is the study of matter, its properties, structure, changes/reactions and the energy that accompanies these changes. Therefore, studying chemistry, whether teaching, demonstration or chemical experimentation, cannot be separated from changes in color, changes in temperature, and changes in other chemical and physical properties. In fact, most observations and analyzes in chemistry are associated with color changes that occur [1–3]. Color change can be said as an indicator of the occurrence of chemical reactions in the gas phase, solution, or solid.

Analysis and measurements in chemistry that take advantage of the color change characteristics are said to be colorimetric analysis (such as titrimetric, spectrophotometry, etc.). In summary, colorimetric analysis is a method for determining the concentration of a chemical substance in a solution with the help of a color reagent or indicator [4–10]. This analytical method measures the amount of a substance present in a sample, based on the amount of light absorbed by the substance (or the amount of light transmitted and captured by the detector).

However, this colorimetric analysis certainly cannot be done if the observer has visual limitations such as color blindness. In addition, not all schools have adequate colorimetric

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equipment or even in some schools, such as schools in the interior of Indonesia, do not have chemistry laboratories and chemical experiment equipment at all. Therefore, it becomes a challenge to create a simpler colorimetric experimental tool, with materials that are easily available, but with a high level of measurement accuracy.

2 Method

This research uses tools and materials that are simple and easy to obtain in standard chemical experiments such as used cardboard, green screen laptop as a light source, test tubes, potassium permanganate solution, oxalic acid, NaOH, indicator, stative, clamps. The development of this color sensor uses an RGB color database where the software construction is based on determining the unknown concentration of a colored solution using the Lamber-Beer principle. Solutions with different concentrations will produce different colors. The higher the concentration, the darker the color of the solution. Therefore, the source of the green color that is absorbed and transmitted will also be different for each solution. Furthermore, the number of RGB colors that are transmitted will be captured by the color sensor application and compared with the RGB color of the blank solution (aquades) to produce the absorbance value of the solution. The concentration and absorbance values are plotted in a straight line based on the Lambert-Beer equation as follows:

$$A = \varepsilon bc$$

where is the molar absorptivity, b is the length of sample in which light source travels, c is concentration of the solutions and A is absorbance. Based on this equation, it can be understood that the absorbance is directly proportional to the concentration of the solution.

3 Results and Discussion

The results showed that the developed color sensor application has been successfully applied for experiments to determine the concentration of colored solutions based on Lambert-Beer law and acid-base titration experiments. In the experiment of determining the unknown concentration of $KMnO_4$ solution, plotting between concentration versus absorbance produces excellent results which are indicated by very high linearity of the curve. Furthermore, to test the accuracy of three samples of colored solution whose concentration is not known, the data obtained are as follows (Table 1).

In the acid base titration experiment, this application has succeeded in being a "warning alarm" for the observer to determine the end point of the titration. The application will emit a beep sound and the phone will vibrate if it detects the colors that have been scanned and recorded in the color database before the titration experiment is carried out as shown in Fig. 1.

Furthermore, the researchers also asked for responses from experts in the field of Chemistry and Chemistry Education on the developed color sensor application. The question items include:

Table 1. Test the Accuracy of Three Samples of Colored Solution

No	$[KMnO_4]$ / 10^{-5} M	Calculated /10^{-5} M	Error (%)
1	7.5	7.415	1.13
2	10	9.942	0.58
3	12.5	12.558	0.46

Fig. 1. Acid-base titration experiment

- Is the simple smartphone-based colorimeter application developed useful for determining the unknown concentration of a colored solution?
- Is the simple smartphone-based colorimeter application developed useful as a "warning alarm" for determining the end point of an acid-base titration?
- Does the application developed have high accuracy?
- Is the application developed easy to understand and easy to use?
- Is the application developed suitable for use in teaching, practicum and demonstration of chemistry?
- Is the application developed useful for chemistry students who have visual impairments (visual disabilities)

Four Experts responses to the application, they are chemistry lecture from Universitas Gadjah Mada, UIN Raden Fatah Palembang, Universitas Papuan, dan Akademi Farmasi Yarsi Pontianak. The results show that almost all respondents agree that the developed application is useful for determining the unknown concentration of a colored solution and as a "warning alarm" for determining the end point of acid-base titrations. Almost all respondents also agreed that the developed application has very high accuracy and is easy to use.

All respondents strongly agree about the feasibility of the application of color sensors to be applied in teaching, practicum and demonstration of chemistry in front of the classroom. Finally, all respondents also agreed that this application is very good to use for chemistry students who have visual disabilities. Respondent answers were presented in Fig. 2.

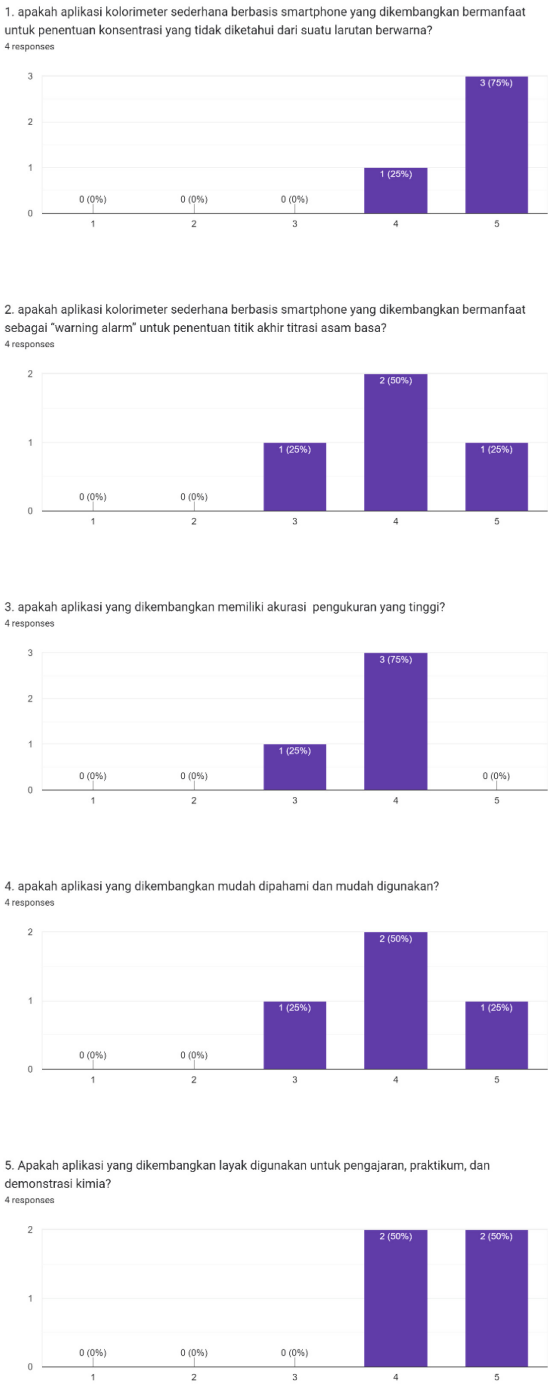

Fig. 2. Expert response to the application

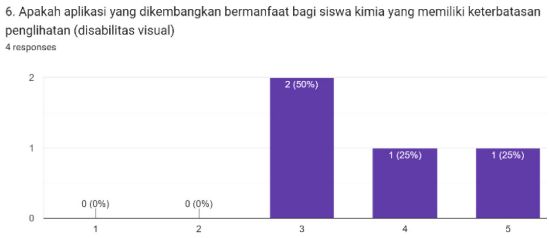

Fig. 2. (*continued*)

4 Conclusion

Colorimetric applications based on RGB color detector have been successfully developed. Test results on samples of colored solutions confirm the accuracy of this application with a measurement rate of ~99%. The beep and vibrate sound feature in this application also helps the Education of chemistry students to determine the end point of titrations in acid-base experiments. This application is also highly recommended for teaching and practicum colorimetry in schools.

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