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## Constructing a simple electrolyte conductivity meter for chemistry learning

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**Abstract.** This research is based on the idea of the need for an innovative experimental learning media in the study of physical chemistry on electrolyte solutions conductivity concept. Through Research and Development method with the stages of analysis, design and development, a simple electrolyte conductivity measurement device has been produced. Based on the results of the research, the product was obtained in the form of an electrolyte solution conductivity measuring device that equipped with a user guidebook and an experimental worksheet of the electrolyte solution conductivity measurement. The electrolyte solution conductivity device is designed to measure the conductivity of an electrolyte solution. This measurement device is able to compare the conductivity value of fruit juices, vegetable juices and isotonic drinks quantitatively based on Kohlrausch's law with simple and easy devices and materials. The validation result shows that the product is valid. The product was tested to chemistry education students using a feasibility test instrument. The result shows that the average of the value of the feasibility test is 93.85%. These results indicate that the constructed electrolyte conductivity meter is feasible to be used.

### 1. Introduction

Electrolyte and non-electrolyte solutions subject is very closely related to daily life, so it is very necessary to be mastered by students [1]. Students can conduct experiments using samples that are often encountered in everyday life in order to find itself characteristic differences between strong electrolyte and weak electrolyte [2]. In general, to detect whether the solution is a weak electrolyte or a strong electrolyte, a device equipped with incandescent light can be used. This device measures the conductivity of the electrolyte solution by observing the dim or bright light on the device [3]. Learners can use these devices easily, except that the results obtained are still qualitative in nature and cannot compare electrolyte concentrations or dissociation rates [4].

Based on the elaboration, the authors are interested in developing media for chemistry learning about the conductivity of electrolyte solutions. The media will be developed in the form of electrolyte solution conductivity meter made from simple materials that are easily available and affordable [4]. This media has advantages, i.e. the modification of electrolyte solution conductivity measurement device can be made easily from simple materials. The device can be a solution to tackle the lack of facilities and infrastructure in the laboratory so that experiments can still be conducted, thus the use of this media does not eliminate experimentation as a feature of science [5].

This conductivity measurement device for electrolyte solutions can explain the characteristics of electrolyte solutions quantitatively [4]. In line with the learning activities that will be carried out, it is



also necessary for inquiry-based experimental worksheets that can facilitate the process of learning activities [6]. An appropriate worksheet with research format was also prepared in this research.

## 2. Methods

This study used research and development method, aims to produce products, then tested for the effectiveness of the product. This method aims to develop educational materials designed to support learning. The product is an electrolyte solution conductivity measuring instrument that can be used to help students in chemistry learning process. This method refers to the ADDIE model, i.e. analysis, design, development, implementation and evaluation [6,7]. But in this study, only the first three stages were used.

The first step is to analyze the problem or identify the needs for developing learning media and worksheets that are creative and innovative. Then decide on the chemical concepts that will be focused on, i.e. conductivity of electrolyte solutions concept. The second step is to design the electrolyte solution conductivity meter in chemistry learning. The stages are as follows:

- make a design of the electrolyte solution conductivity meter.
- arrange the stages of making electrolyte solution conductivity measuring instruments and design the user guide and worksheet.
- the results of the design are consulted by the supervisor to get input and suggestions.

At the stage of development, what was done was making the conductivity meter and experimental worksheets on the conductivity of electrolyte solutions concept. An assessment instrument was also made to determine the quality of the product developed. After that, the instrument validation test was done by expert lecturers. The initial product was then revised to be used at the implementation stage.

## 3. Results and discussion

Overall, there are two stages needed to produce an electrolyte conductivity meter. The first stage is planning the design of electrolyte solution conductivity measuring devices. The next stage is the development of designs to produce products and the appearance of electrolyte solution conductivity measuring devices. The results of these two stages are described as follows:

### 3.1. Design for electrolyte conductivity measurement device, user guide, and worksheet

3.1.1. Design of electrolyte conductivity measurement device. The electrolyte conductivity measurement device's design refers to electrolyte conductivity measuring devices that have been developed in previous studies [4]. The design of a conductivity measuring instrument for electrolyte solutions that already exists then repaired and redesigned with new innovations. The components contained in the design set of electrolyte solution conductivity measuring instruments are variable resistors which can be seen in Figure 1(a), two electrodes and solution containers that can be seen in Figure 1(b), and the combination of fixed resistors and piezoelectric buzzers is shown in Figure 2. Overall, the display design of electrolyte solution conductivity measuring sets can be seen in Figure 3.

Furthermore, the design where the measuring instrument is adjusted to the size of the components that will be placed in it. The material used to make the electrolyte solution conductivity measuring place is fiberglass. The description of the appearance of a conductivity meter can be seen in Figure 4.



Figure 1. (a) variable resistor design (b) reaction tube design.

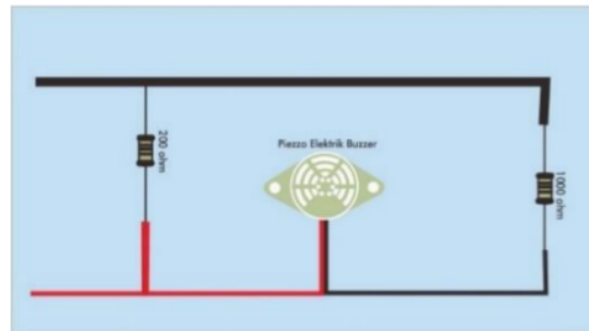


Figure 2. Piezoelectric buzzer design.

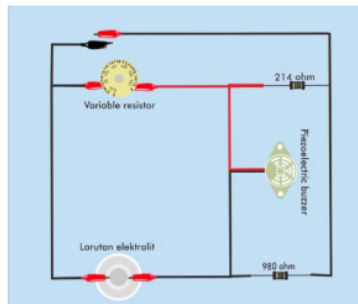


Figure 3. design of electrolyte solution conductivity measuring sets.

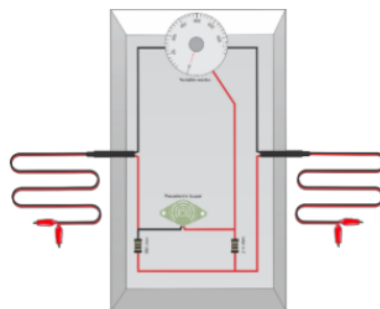


Figure 4. Display of electrolyte solution conductivity measurement design.

3.1.2. *Design of the user guide.* The user guide is created using an image processing and word processing application. The size of the paper used is 11 cm × 17 cm with the book background full color to make it look attractive. The user guide contents was written in a straightforward manner, consist of covers, preface, table of contents, components of the device and their functions, how to assemble the measurement device and and how to use the device for measuring conductivity.

3.1.3. *Worksheet design.* The next stage is the preparation of worksheet instruments. On the worksheet there are titles, student identity, text/discourse about conductivity concept, eleven questions and commands that must be solved by students. The discourse on the worksheet contains information on the role of electrolyte solutions, the definition of electrolytes, the definition of the conductivity value of a

substance, the principle of measuring the conductivity of an electrolyte solution, and the formula for calculating the conductivity value of a solution.

### 3.2. Development of electrolyte conductivity measurement device

The design of the electrolyte conductivity measuring device which has been designed is then developed. During the development phase the device is also accompanied by the development of a user guide and worksheet. The initial product was validated by three validators. Validated products will be tested on students. As for the appearance of the final product the electrolyte solution conductivity meter can be seen in Figure 5.



**Figure 5.** Display of electrolyte solution conductivity measuring device.

The next step is to conduct a device optimization test by researchers in the laboratory with several samples of electrolyte and non-electrolyte solutions i.e. NaCl (aq), CuCl<sub>2</sub> (aq), glucose, urea, isotonic drinks, carrot juice, tomato juice, and orange juice. The device was tested for the ability to measure effect of concentration on solution conductivity.

**3.2.1. Effect of concentration on the conductivity value of the solution.** The conductivity measurement of the electrolyte solution was carried out using an electrolyte conductivity measuring device that had been made. The sample to be tested is inserted into the tube to the ring boundary, the two electrodes are clamped with a crocodile clamp. Then the electrolyte conductivity meter is connected to the power supply (AC), the power button on the power supply is turned on at a voltage of 9 volts.

Piezoelectric buzzer on a measuring instrument will sound at zero resistance value. The pointing device is rotated manually until the piezoelectric buzzer hardly sounds or until it is silent. The pointer will show the value of the receipt and the value is written as R<sub>low</sub>. The pointer of the resistance value is turned back until the piezoelectric buzzer sounds louder than before, the value of this resonance is written as R<sub>high</sub>.

Measurements was conducted on each of this solution: NaCl, AlCl<sub>3</sub>, CuCl<sub>2</sub>, glucose, and urea with various concentrations, i.e. 0.01 M, 0.012 M and 0.014 M. Each of these solutions was tested three times to obtain the accuracy of the conductivity value of the solution. The overall conductivity value of the electrolyte solution can be seen in Table 1. From the measurement data the effect of concentration on the conductivity value of the solution in Table 1, the conductivity value of NaCl (aq) solution 0.01 M, 0.012 M, and 0.014 respectively was  $1.998 \times 10^{-3} \text{ S.cm}^{-1}$ ,  $2.146 \times 10^{-3} \text{ S.cm}^{-1}$  and  $2.317 \times 10^{-3} \text{ S.cm}^{-1}$ . The conductivity value of CuCl<sub>2</sub> solution from the smallest to largest concentration was  $2.236 \times 10^{-3} \text{ S.cm}^{-1}$ ,  $2.422 \times 10^{-3} \text{ S.cm}^{-1}$  and  $2.5992 \times 10^{-3} \text{ S.cm}^{-1}$ . From these data it can be seen that the conductivity value increases with increasing concentration of electrolyte solution. High conductivity values indicate high electrolyte levels [3].

**Table 1.** Experimental results data effect of concentration on the conductivity value of the solution.

Sample	Concentration	$R_{low}$	$R_{high}$	$R_x$	$K (S.cm^{-1})$
NaCl	0.01	65	96	368.69	$1.985 \times 10^{-3}$
	0.01	71	89	366.4	$1.998 \times 10^{-3}$
	0.01	72	88	366.4	$1.998 \times 10^{-3}$
	0.012	65	84	341.21	$2.146 \times 10^{-3}$
	0.012	65	84	341.21	$2.146 \times 10^{-3}$
	0.012	63	85	338.92	$2.160 \times 10^{-3}$
	0.014	57	81	316.02	$2.317 \times 10^{-3}$
	0.014	56	82	316.02	$2.317 \times 10^{-3}$
	0.014	56	82	316.02	$2.317 \times 10^{-3}$
CuCl <sub>2</sub>	0.01	65	78	327.47	$2.236 \times 10^{-3}$
	0.01	66	77	327.47	$2.236 \times 10^{-3}$
	0.01	65	78	327.47	$2.236 \times 10^{-3}$
	0.012	56	75	299.99	$2.440 \times 10^{-3}$
	0.012	55	77	302.28	$2.422 \times 10^{-3}$
	0.012	55	77	302.28	$2.422 \times 10^{-3}$
	0.014	53	70	281.67	$2.5992 \times 10^{-3}$
	0.014	52	71	281.67	$2.5992 \times 10^{-3}$
	0.014	53	70	281.67	$2.5992 \times 10^{-3}$

3.2.2. *Comparison of the conductivity value of isotonic drinks with fruit juices and vegetable juices.* In this experiment, the sample of the solutions to be tested were isotonic drinks, carrot juice, tomato juice, orange juice and watermelon juice. Each solution sample was tested three times until a constant  $R_{low}$  and  $R_{high}$  value was obtained. Data from observations in the form of numbers obtained from several experiments that have been carried out using the conductivity measuring device. The data obtained was the value of  $R_{low}$  and  $R_{high}$  which will be processed to obtain the conductivity value of the solution. Overall the conductivity value of isotonic drinks, fruit juices and vegetable juices can be seen in Table 2.

**Table 2.** Results of experimental data comparison of the conductivity value of isotonic drink, fruit juices and vegetable juice.

Sample	$R_{low}$	$R_{high}$	$R_x$	$K (S.cm^{-1})$
Isotonic Drink	75	125	485	$1,5985 \times 10^{-3}$
	75	125	485	$1,5985 \times 10^{-3}$
	75	125	485	$1,5985 \times 10^{-3}$
Orange Juice	70	120	435,1	$1,6826 \times 10^{-3}$
	70	120	435,1	$1,6826 \times 10^{-3}$
	70	120	435,1	$1,6826 \times 10^{-3}$
Tomato Juice	55	70	286,25	$2,5576 \times 10^{-3}$
	55	72	290,83	$2,5173 \times 10^{-3}$
	55	70	286,25	$2,5576 \times 10^{-3}$
Carrot Juice	50	90	320,6	$2,2836 \times 10^{-3}$
	52	90	325,18	$2,2514 \times 10^{-3}$
	50	90	320,6	$2,2836 \times 10^{-3}$

The highest conductivity values were achieved by tomato juice with a conductivity value of  $2.481 \times 10^{-3} S.cm^{-1}$ , carrot juice  $2.2 \times 10^{-3} S.cm^{-1}$ , orange juice  $1.632 \times 10^{-3} S.cm^{-1}$  and isotonic drink with conductivity values of  $1.55 \times 10^{-3} S.cm^{-1}$ . The data show that fruit juices and vegetable juices have a higher conductivity value than isotonic drink, so fruit juices and vegetable juices are better consumed by the body as ion substitutes, because high conductivity values indicate high electrolyte levels [3].

The next stage is the making of a manual. The user guide consists of covers and parts of contents, namely the function of components, manufacturing procedures and procedures for using props. The user guide is created using an image processing and word processing application.

*3.2.3. User guide and worksheet.* After user guide validated by the experts, supporting images were added to the user guide to make the user guide cover look more attractive and briefly describe the contents of the manual. The function of the electrolyte solution conductivity measuring components were written on the start page, contains the introduction of device components equipped with images and functions and other additional information for each component of the device. The procedure for assembling the measuring device (as previously stated) was also written clearly in the user guide. The procedure for using the electrolyte conductivity meter was written on the last page. The procedure is made with a language that can be understood by the reader in measuring the conductivity value of an electrolyte solution.

Worksheet serve as a guide to the use of electrolyte conductivity measuring device and also contain several questions that guide students to be able to know the effect of concentration on conductivity value and compare isotonic drinks with fruit juice and vegetable juice to find good drinks consumed as ion substitutes in the body. This experimental worksheet measures the conductivity of electrolyte solutions using the device that have been made, there are additional instructions and questions that aim to guide students to be more critical in thinking, can explore the concepts themselves that are being studied and so that the worksheet is more systematic so that students are easier in the process of learning.

The validation test on the measuring device, user guide, and experiment worksheet was conducted by the expert lecturers as a validator to get an assessment and suggestion for improvements. Technical validation was done by showing the measuring instrument products that have been made along with the instruments, i.e. the experimental worksheet, the conductivity measurement of the electrolyte solution and the questionnaire sheet. The average results of the electrolyte conductivity measurement validation can be seen in Table 3. Feasibility test was conducted via limited trial by ten students from Chemical Education major who have attended Physical Chemistry II lectures. In this feasibility test, students assessed the electrolyte solution's conductivity measurement in chemistry learning with several aspects. Average feasibility test results are shown in Table 4.

Overall for the results of the validation of the electrolyte conductivity measurement in chemistry learning it was declared valid with a high enough interpretation by obtaining an average value of 0.83 [4]. This is also supported by the results of the feasibility of the electrolyte solution conductivity kit based on the assessment of the questionnaire given to the respondents obtaining an average percentage of 93.85%. Figures obtained by the electrolyte conductivity measurement included in the criteria are very feasible and ready to be used as learning media. It can be concluded that the constructed electrolyte conductivity measurement device can also facilitate students to understand the conductivity of electrolyte solutions concept.

**Table 3.** Average results of assessment aspect validation of electrolyte conductivity measurement device.

No	Aspect	Average
1	Aspects of Conformity with Material	0,87
2	Aspects of Practical and Dexterity	0,87
3	Aspects of Resilience device	0,73
4	Aspects of device efficiency	0,87
5	Aspects of safety for students	0,87
6	Aspect of esthetics	0,80
7	Aspect of kit box	0,87
8	Aspects of users guide book	0,80



**Table 4.** Average feasibility test results of electrolyte conductivity measurement device.

No	Aspects	Average of Feasibility Test (%)	
		Yes	No
1	Aspects of Conformity with Concept	100	0
2	Aspects of Practical and Dexterity	100	0
3	Aspects of Resilience device	85	15
4	Aspects of devices efficiency	100	0
5	Aspects of safety for students	90	10
6	Aspect of esthetic	90	10
7	Aspect of kit box	96,67	3,33

#### 4. Conclusion

The constructed electrolyte conductivity meter can measure the conductivity of the electrolyte solution with a concentration of 0.01 M - 1 M. The product is equipped with a user guide that contains the functions of the components and materials, how to use the device and how to calculate the electrolyte solution conductivity value. The results of the validation test obtained an average yield of 0.83 and the results of the feasibility test the respondents obtained an average percentage of 93.85%. This shows that product was valid and very feasible to be used as a chemistry learning media.

#### References

- [1] Doymus K, Karacop A and Simsek U 2010 Effects of jigsaw and animation techniques on students' understanding of concepts and subjects in electrochemistry *Educational Technology Research and Development* **58**(6) 671–691
- [2] Irsanti R, Khaldun I and Hanum L 2017 Identifikasi Miskonsepsi Siswa Menggunakan Four-Tier Diagnostic Test pada Materi Larutan Elektrolit dan Larutan Non Elektrolit di Kelas X SMA Islam Al-falah Kabupaten Aceh Besar Abstrak Pendahuluan Metode Penelitian *Jurnal Ilmiah Mahasiswa Pendidikan Kimia (JIMPK)* **2**(3) 230–237
- [3] Luh S, I Wayan M 2013 Analisis Standar Laboratorium Kimia Terhadap Capaian Kompetensi Adaptif di SMK Negeri 2 Negara *E-Jouenal Program Pascasarjana Universitas Pendidikan Ganesha* **3** 1–11
- [4] Set S and Kita M 2014 Development of a Handmade Conductivity Measurement Apparatus and Application to Vegetables and Fruits *Journal of Chemical Education* 1–6
- [5] Hofstein A and Mamlok-Naaman R 2007 The laboratory in science education: the state of the art *Chem. Educ. Res. Pract.* **8**(2) 105–107
- [6] Lee T T and Osman K 2012 Interactive multimedia module with pedagogical agents: Formative evaluation *International Education Studies* **5**(6) 50–64
- [7] Hess A K N and Greer K 2016 Designing for Engagement: Using the ADDIE Model to Integrate High-Impact Practices into an Online Information Literacy Course *Communications In Information Literacy* **10**(2) 264–282

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