The conception of pre-service chemistry teachers on chemistry contents in the context of conductive glass

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Abstract. The purpose of this study is to obtain the conception of pre-service chemistry teachers related to chemical contents in the context of conductive glass investigated through didactic design. Descriptive research method was chosen as the method in this study and the analysis was carried out quantitatively and qualitatively with 27 participants of the fourth semester at one of the universities in Bandar Lampung. The instrument used were 11 essay questions covered in 7 different discourses. The obtained results will be used as preference to make didactic design in the context of conductive glass. Based on student answers, it is known that 70.4% still have a low understanding on resistivity and semiconductor concepts. The low level of understanding shows that there are still many students who do not understand the chemical contents as basic knowledge for -making didactic design to teach chemical contents in the context of conductive glass.

1. Introduction
PISA (Program of International Student Assessment) is one of the assessment methods to evaluate student’s scientific literacy and skills. Based on PISA 2015, it mentioned that Indonesian students still demonstrate very low achievement on PISA of level 1 to 6 where 1.2% below level 1; 14.4% at level 1b; 40.4% at level 1a; 31.7% at level 2; 10.6% at level 3; 1.6% at level 4; 0.1% at level 5 and none reaches level 6 [1]. It indicates that student’s ability to use science in complex problem solving still very unsatisfied. Additionally, Suprapto (2016) said that students in Indonesia have a little understanding of science-global issues, less content knowledge and less ability to explain phenomena, interpret data and evidence scientifically [2].

Improvement of student understanding on scientific concepts as well as scientific process skills is crucial to overcome the issue mentioned above [3]. Involvement of technology aspects can stimulate student’s curiosity and motivation in science learning [4]. The relationship between science and technology known as technoscience. Particularly, in chemistry learning, this approach named as technochemistry [5].

One of the examples of technochemistry concepts is conductive glass. This material is widely used in technologies such as solar cells, touch screens, display technology, and functional glass window applications [6]. Conductive glass has been widely made by scientists using a variety of potential
compounds such as Indium Tin Oxide (ITO) and Fluorinated–Tin Oxide (FTO). In term of application, FTO conductive glass is preferable because it is cheaper selling price than ITO [7]. The conductive glass has characteristic to transmit visible light spectrum and high conductivity [8]. One of the techniques to prepare conductive glass is spray pyrolysis. In particular, this technique involves decomposition of tin salts into tin oxide by means of heat treatment [4].

Didactic design is used to illustrate communication, interaction, and documentation in teacher-student relationship [9]. This design can be considered as an aspect of high-level thinking of educators and as a practical exercise in the community by utilizing evolving technology. Furthermore, this design can be used as one of the learning designs if the educators want to teach chemical contents technology-based (technochemistry). One of the technochemistry contexts that can be taught with didactic design is conductive glass. The purpose of this study is to obtain the student’s conceptions in the context conductive glass which investigated through didactical design.

2. Methods
The method was chosen by researchers is descriptive method. The research was conducted at one of the universities in Bandar Lampung with 27 participants of fourth semester. The participants were given 11 essay questions. Hereafter, the student’s answers were analyzed quantitatively and qualitatively, to obtain the of student’s difficultness on chemistry learning. This information is very useful to develop didactic design for chemistry learning in the context of conductive glass.

3. Result and Discussion

3.1. Student Understanding regarding Concepts in The Context of Conductive Glass
Students understanding on chemistry concepts in the context of conductive glass were categorized into 7 concepts namely 1) semiconductor material; 2) resistivity; 3) doping; 4) n-type semiconductors; 5) p-type semiconductors; 6) suitable methods of making conductive glass; and 7) conductive glass applications. The students’ understanding on those concepts presented in Table 1.

Table 1. Results of Student Understanding on Essay Tests

| Category     | Score  | Number of Students | Percentage (%) |
|--------------|--------|--------------------|----------------|
| Very Good    | 80-100 | 0                  | 0.0            |
| Good         | 61-80  | 1                  | 3.7            |
| Fair         | 41-60  | 7                  | 25.9           |
| Low          | 21-40  | 14                 | 51.9           |
| Very Low     | 1-20   | 5                  | 18.5           |

Based on Table 1, it indicates that students still have weakness in the concepts of resistivity and semiconductors. The answers given by students are only related to the definition of these concepts in general. Table 2 represents the student’s understanding on chemistry concepts in the context of conductive glass.

Table 2. Distribution of Student’s Understanding on Chemistry Concepts in Context of Conductive Glass

| No | Content          | Percentage (%) | Average (%) |
|----|-----------------|----------------|-------------|
| 1  | Semiconductor   | 37.0           |             |
|    | material        |                |             |
| 2  | Resistivity     | 33.3           |             |
| 3  | Doping          | 29.6           |             |
Based on Table 2, it can be said that students' understanding of the whole concept is still weak related to the context of conductive glass. This is because these concepts are still not understood by students and the context of conductive glass is still not widely known by students. So that they have difficulty when asked to explain the working principles and benefits of these technologies in life. This is supported by Bell et al. (2012) that science learning for students should necessarily be rooted in experiences that represent sensible versions of the work of scientist [10]

3.2. Resistivity

Resistivity is one concept that can be studied in the context of conductive glass. This concept is related to conductivity. Based on student answers, it is known that students have been good enough in analyzing the given discourse, but they have not been able to connect between resistivity and conductivity in a material. The distribution of student’s understanding on resistivity concept presented in Table 3.

Table 3. The Distribution of Student’s Understanding on Resistivity Concept

| Student Answers                                                                 | Percentage (%) |
|---------------------------------------------------------------------------------|----------------|
| Resistivity and conductivity have relationships that are mutually opposite to each other | 44.5           |
| Resistivity and conductivity have relationships that are mutually opposite to each other. The higher the conductivity or the smaller the resistivity, the better the material will conduct electricity | 33.3           |
| No answer                                                                       | 22.2           |

Based on Table 3, information is obtained that student answers related to the concept of resistivity is vary. First, students are only able to answer the relation between resistivity and conductivity are opposite to each other. Their answers have not led to the relation between these two in a material (conductive glass). Second, there is already a student answer that is considered appropriate, namely resistivity and conductivity having opposite relation. The higher the conductivity or the smaller the resistivity, the better the material is in delivering electricity.

The weakness of students in answering this question shows that this concept is not enough to be taught in theory alone, but also requires practicum activities. Research conducted by Compton et al. shows that teaching the concept of conductivity can be through practical activities as a topic that can be discussed, does not require expensive tools and materials, and real world based projects [11]. The concept of resistivity and conductivity needs to be well understood by students as one of the concepts that can be learned in the context of conductive glass. This is because the application of conductive glass which depends on its conductivity value can be used as a collector of electric currents, such as solar cells and as a transparent electrode for charging and using smart electrochromic windows [12].
3.3. Semiconductors

The concept of semiconductors is closely related in the context of conductive glass. This is because in the manufacture of conductive glass using semiconductor oxide compounds, such as ZnO, SnO$_2$, and In$_2$O$_3$ [13]. The choice of oxide compounds depends on the characteristics of the technology that will be made later. In the instruments made, the semiconductor concept, doping and semiconductor materials. The distribution of student’s understanding on Semiconductor Materials presented in Table 4.

| Student Answers                        | Percentage (%) |
|----------------------------------------|----------------|
| Conductive glass can conduct electricity because it contains semiconductor oxide | 37.1           |
| No answer                              | 62.9           |

Based on Table 4, information is obtained that student answers related to semiconductor material in a conductor glass have not reached the right answer. Students are only able to answer the reason that conductive glass can conduct electricity due to the presence of semiconductor oxide compounds. When students are given further questions about why the oxide compound can conduct electricity, they have not been able to answer it. The low ability of students to answer these questions shows that semiconductor learning is needed. This is supported by research conducted by Sihar et al. that there are more than 17.4% of students having difficulty in answering questions related to semiconductor basics [13].

The second coverage of the semiconductor concept is doping. Semiconductor oxide compounds can be given as dopants to increase their conductivity. It is intended that the technology produced has the ability to deliver electricity better. The distribution of student’s understanding on doping and dopants presented in Table 5.

| Student Answer                          | Percentage (%) |
|----------------------------------------|----------------|
| Doping is the addition of impurities in the semiconductor so that it can change the electrical properties while the dopant is impurity | 29.6           |
| No answer                              | 70.4           |

Based on Table 5, information was obtained that students' answers to doping and dopants had been answered correctly by several students. Most students still have difficulties in defining doping and dopants because of their lack of understanding. This result is in line with the research conducted by Wettergren that there are still many students who show incorrect or imperfect understanding when they are interviewed regarding the concept of doping [14]. The student's conception of doping needs to be submitted because of the doping relation with the value of resistivity from conductive glass. This is like the research conducted by Huang et al. that the use of several percent elements of W (tungsten) as a dopant can reduce SnO$_2$ resistivity to reach $5.8 \times 10^{-3}$ ohm.m [15].

Then, students were also asked to answer questions about the selection of the right anion used as a dopant on the semiconductor compound SnO$_2$ based on the table of values of the atomic and anion radii of the VIA and VIIA group elements. Based on the results of the analysis of student answers that they are only able to answer the correct anion is F$^-$ and do not explain that the similarity of the anion radii is used as the explanation. The ion radii of F$^-$ is 0.71 while the radii of the O$^{2-}$ ion is 1.40. This value indicates that both have a size that is not much different and will not affect the structure of the SnO$_2$ too much. This is also supported by a statement disclosed by Perkins that the crystal lattice of SnO$_2$ is
slightly affected by the substitution of $O^2-$ by $F^-$ due to the similarity of the radii of oxygen and fluorine ions [12].

The third coverage of the semiconductor concept is the types of semiconductors. Doping carried out on semiconductor compounds consists of two types, n-type semiconductor and p-type semiconductor. The choice of the type of semiconductor to be carried out depends on the semiconductor compound. The distribution of student’s understanding on the differences in n-type semiconductors and p-types presented in Table 6.

### Table 6. The Distribution of Student’s Understanding on Types of Semiconductors

| Student Answers | Percentage (%) |
|-----------------|----------------|
| An n-type semiconductor is a semiconductor that is given a dopant whose dopant band is closer to the conduction band and the impurity (dopant) as an electron donor. P-type semiconductors are semiconductors that are given a dopant whose dopant band is closer to the valence band and impurity (dopant) as an electron acceptor | 25.9 |
| No answer | 74.1 |

Based on Table 6, information is obtained that some students are able to explain the differences between n-type and p-type semiconductors. In fact, there are answers that write examples. However, the answers given by this student have not been related to the discourse that is included. Students have not been able to explain the differences between the two types of semiconductors in the discourse related to $\text{SnO}_2$ compounds given dopants $F^-$ and $\text{Fe}^{3+}$. This shows that students do not quite understand the differences between the two types of semiconductors by only reading a discourse. The research conducted by Dangur et al. shows that students can better understand n-type and p-type semiconductors when given an illustration in the form of an image [16].

The difficulties that arise based on the answers of these students form the basis for researchers to design a didactic design related to chemical concepts in the context of conductive glass. In this learning various media can be provided to help students better understand these concepts. The research conducted by Mudzakir et al. revealed that chemical concepts such as semiconductors, molecular orbital theory, and ribbon theory in the context of conductive glass can be taught with the help of laboratory-based worksheets. The worksheet contains activities that require students to be able to design their own practice for making conductive glass [4].

### 4. Conclusion

Based on the result of the study, we get information that the conception of pre-service chemistry teachers related to chemical contents in the context of conductive glass are still weak. Furthermore, this context is still not widely known by students and these results can be the basic for researchers to develop didactic design. This design can be used as an alternative for educators in an effort to improve student conceptions in the context of conductive glass.

### 5. References

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