Pre-service chemistry teachers’ VNOST and their conceptions about the context of OLED and related chemistry contents

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Abstract. This study aims to analyze the pre-service chemistry teachers’ (PCTs’) views of nature of science and technology (VNOST), as well as to analyze their conceptions about the context of organic light-emitting diodes (OLED) and the related chemistry contents. As a part of a larger study, this study is the second stage of the Model of Educational Reconstruction, which involved 41 PCTs. A modified questionnaire of VNOST from Tairab and Aikenhead was administered to assess the PCTs’ VNOST. Meanwhile, a validated interview guidelines were used to gather some information about the PCTs’ conceptions about OLED as well as their understanding about chemistry concepts corresponded to OLED. PCTs’ VNOST are classified into Realistic, Has Merit, and Naïve. The result shows that most of the PCTs have the VNOST level as Has Merit. Furthermore, according to the interview result, the PCTs still have limited understanding about OLED and also suggest that the PCTs still have fragmented understanding about chemistry concepts such as electrochemistry, reduction-oxidation reaction, and the relation between chemical bonding to the physical properties. We believe that this research will be useful in increasing the PCTs’ VNOST, as well as their conceptions of the context of OLED and the related chemistry contents.

1. Introduction

Based on the 2015 Indonesia Program for International Student Assessment (PISA) survey, Indonesia is ranked 62 out of the 70 participating countries [1]. This shows that the ability of scientific literacy of Indonesian students is low. The low literacy skills of Indonesian learners need to be viewed as a serious problem. Furthermore, a good and comprehensive problem solving should be found soon.

To solve the problem, we need to know the main part of scientific literacy, that is the nature of science (NOS) [2]. Several studies have also revealed that there is a relationship between NOS and scientific literacy [3,4]. Teachers will find difficulties to help learners to have good scientific literacy skills if the teachers themselves have lack understanding of the NOS [5].

In line with the importance of NOS in education, it is also known as the nature of technology (NOT) which is also important in education. The idea of NOS cannot be understood properly without regard of the role of technology [6].

Mastery of Nature of Science and Technology (NOST) can be enhanced through Technoscience [6]. The concept of technoscience is understood as a way of knowing and acting, and is the basis for a
modern approach to the philosophy of science [7]. Technoscience helps to understand the epistemic and cognitive side of technology as well as how the techniques combine both sides with practical and social value [6]. In chemistry, the term Technoscience was introduced by Technochemistry [7].

The technochemistry chosen in this study was ionic liquids (ILs) because ILs are an emerging area of science and technology research. Moreover, ILs can be used to reinforce school chemistry learning content because the scientific explanation of ILs is seen to contain many facts, concepts, principles, laws, models and theory [8]. ILs are widely developed and applied to various aspects of modern technology [9]. Modern technology based on ILs can also be used as a discourse to empower students’ science attitudes [8]. One aspect of ILs technology can be found in organic light-emitting diode (OLED) devices as electrolytes.

In previous research it was shown that students' understanding of the nature of science and technology is still inadequate [10]. In Indonesia, related research has been conducted and the results show that some prospective teachers have naïve views in the NOST aspect [11]. Whereas, the teacher's view will affect students' understanding [5,12]. Regarding this condition, this study aims to analyze the views of pre-service chemistry teachers (PCTs) on NOST, as well as to analyze their conceptions of the context of organic light-emitting diodes (OLEDs) and the related chemistry content.

2. Method
As a part of a larger study, this study is the second stage of the Model of Educational Reconstruction (MER) [13]. The participants of this study were 41 PCTs in one of the University in Bandung. The participants were on the 6th semester of Chemistry Education Study Program.

A modified questionnaire of VNOST from Nature of Science and Technology Questionnaire (NSTQ) [5] and View On Science-Technology-Society (VOSTS) [14] was administered to assess the PCTs’ VNOST. Meanwhile, a validated interview guidelines were used to gather some information’s about the PCTs’ conceptions about OLED as well as their understanding about chemistry concepts corresponded to OLED. Table 1 presents one of the items of the VNOST questionnaire.

| Aspects of VNOST | Item Questionnaire | Category |
|------------------|--------------------|----------|
| The purpose of science and scientific research | In your opinion, why do scientists do scientific research? | |
| A. To make a new discovery. | Naïve |
| B. To try out their explanation of why things can happen. | Realistic |
| C. To make something which will help human life. | Has Merit |
| D. To collect as much data as possible, and conclude a scientific law based on that data. | Has Merit |
| E. I do not have enough knowledge to make choices. | Naïve |
| F. I do not know. | Naïve |
| G. None of the above options are fits with my views. | * |

The PCTs’ VNOST in each item are classified into ‘Realistic’, ‘Has Merit’, ‘Naïve’ and ‘Realistic’ views are related to the general view of science, concepts, and the theory of science as a whole. In the view of ‘Has Merit’, there are only certain parts that fit the prevailing concepts and theories of science. ‘Naïve’ is reveal views that are not at all related to the concepts and theories of science that apply [15]. There is an option that is not categorized (*), that is option “none of the above options are fits with my views”. Data obtained were analyzed for each of the items using frequency distribution to characterize the PCTs’ VNOST. Meanwhile, data obtained from interviews of PCTs’ conceptions of the context of OLED and the related chemistry contents were analyzed qualitatively.

3. Result and discussion

3.1. The pre-service chemistry teachers’ Views of Nature of Science and Technology (VNOST)

The PCTs’ VNOST questionnaire is divided into five aspects, namely the characteristics of science and technology, the characteristics of scientific knowledge and scientific theory, the purpose of science and
scientific research, how to acquire scientific knowledge and scientific theory, and the relationship of science and technology.

Table 2 presents the PCTs’ VNOST on the aspects of science and technology characteristics. There are three items related to the characteristics of science and technology, namely the definition of science, the definition of technology, and the difference. The item of definition of science, 31.71% of PCTs have a realistic view, which views that science is a systematic process of investigating and producing knowledge. Meanwhile, 36.59% PCTs have a has merit view, which sees that science is a field of study such as biology, chemistry and physics (7.32%); carrying out experiments to solve problems in the areas of interest (7.32%); and a collection of knowledge that explains the world around us (21.95%). In addition, 21.95% of PCTs have a naïve view of the definition of science.

Table 2. The percentages of PCTs’ VNOST on aspects of science and technology characteristics.

| VNOST Questionnaire Statements | PCTs’ views (%) |
|--------------------------------|-----------------|
| In your opinion, science is .... | 31.71 36.59 21.95 9.76 |
| In your opinion, technology is .... | 17.07 82.93 0 0 |

On an item about the definition of technology, only 17.07% PCTs have a realistic view that technology is creating, designing, developing and testing objects such as tools, tools and scientific instruments. Meanwhile, 82.93% PCTs still have a has merit view, which views that technology is the application of science to improve life (60.98%). Based on these findings, it can be concluded that most PCTs have VNOST at the has merit level on aspects of science and technology characteristics.

Table 3. The percentages of PCTs’ VNOST on aspects of scientific knowledge characteristics and scientific theory.

| VNOST Questionnaire Statements | PCTs’ views (%) |
|--------------------------------|-----------------|
| Which of the following statements correspond to your understanding of scientific knowledge? | 92.68 0 2.44 7.32 |
| In your opinion, the scientific theory is .... | 46.34 39.02 7.32 7.32 |

Table 3 presents the PCTs’ VNOST on aspects of the characteristics of scientific knowledge and scientific theory. There are two items related to the characteristic aspects of scientific knowledge and scientific theory. On items about scientific knowledge, almost all PCTs (92.68%) have realistic view, agreeing that scientific knowledge is a well-organized collection of facts and current scientific knowledge is based on scientific perspective, ideas and interpretations of scientists from the past. Meanwhile, on items about scientific theory, almost all PCTs (46.34%) have a has merit view, which views that scientific theory is the most appropriate interpretation that has been approved by scientists (46.34%). 39.02% PCTs view that scientific theory is a fact evidenced through many experiments (has merit view). From this finding, it can be concluded that although almost all PCTs understand about scientific knowledge, but most of them do not yet understand the scientific theories.

Table 4. The percentages of PCTs’ VNOST on aspects of science objectives and scientific research.

| VNOST Questionnaire Statements | PCTs’ views (%) |
|--------------------------------|-----------------|
| In your opinion, the purpose of science is to .... | 70.73 24.39 4.88 0 |
| In your opinion, why do scientists do scientific research? | 48.78 41.46 2.44 7.32 |

Table 4 presents the PCTs’ VNOST on aspects of science and scientific research objectives. There are two items related to the aspects of science and scientific research purposes. On the item about the goal of science, almost all PCTs (70.73%) have a realistic view, agreeing that the goal of science is to understand, explain and interpret the changes in nature that constantly occur as well as its characteristics.
A total of 24.39% PCTs with a has merit view. 4.88% of naïve view PCTs are those who believe that the goal of science is to ensure that what has been discovered about the world is an essential truth. Meanwhile, on the item about the reasons why scientists conduct scientific research, the percentages of PCTs with realistic and has merit views are almost similar percentage. Most PCTs have a view that the goal of scientists doing scientific research is to test their explanation of why things can happen. The conclusion based on the findings is although most PCTs have an understanding of the purpose of science, many of them still do not understand why scientists do scientific research.

Table 5 presents the PCTs’ VNOST on aspects of how to acquire scientific knowledge and scientific theory. There is only one item that deals with that aspects. A total of 63.41% PCTs have a has merit view. Most of them held that scientific discovery resulted from a logical series of studies because the study began by examining the results of previous experiments to find out if it was true and a new experiment would be reviewed by those who emerged afterwards (41.46%). It can be concluded that most PCTs have VNOST at the has merit level on aspects of acquiring scientific knowledge and scientific theory.

Table 5. The percentages of PCTs’ VNOST on aspects of how to acquire scientific knowledge and scientific theory.

| VNOST Questionnaire Statements                                                                 | PCTs’ views (%)         |
|-----------------------------------------------------------------------------------------------|-------------------------|
| Scientific findings were obtained based on a series of studies. Each study was built based on previous research and each study will lead to further research, to obtain a new finding. Bring up your view of why that might happen. | Realistic 34.15, Has Merit 63.41, Naïve 2.44, Uncategorized 0 |

Regarding the PCTs’ VNOST on aspects of science and technology relationships, there are three items related to the relationship of science and technology (See Table 6). In the first item on the relationship between science and technology, the percentages of PCTs with realistic and has merit views are almost similar percentages. From a number of realistic views, most of the PCTs view that science and technology affect society, but on the other hand society also affects the development of science and technology (87.80%). Meanwhile, from a number of other has merit views, most PCTs believe that technological innovation and/or science development can cause environmental problems such as pollution and acid rain (63.41%).

Table 6. The percentages of PCTs’ VNOST on aspects of science and technology relationships.

| VNOST Questionnaire Statements                                                                 | PCTs’ views (%)         |
|-----------------------------------------------------------------------------------------------|-------------------------|
| The following is a statement about the relationship of science and/or technology in everyday life. Circle all statements that match your opinion. You can circle more than 1 option. | Realistic 48.84, Has Merit 48.06, Naïve 3.10, Uncategorized 0 |
| Technologist/Engineer have their own knowledge domain that can be developed. Few technological developments stem from discoveries made in science. | Realistic 41.46, Has Merit 56.10, Naïve 2.44, Uncategorized 0 |
| Science and technology have a very close relationship with each other. Both are interconnected because .... | Realistic 39.02, Has Merit 48.78, Naïve 9.76, Uncategorized 2.44 |

In the second item on the relationship between science and technology, 41.46% PCTs has a realistic view that technological progress refers to two things that have a balanced role, namely scientific discovery and knowledge of technology itself. However, more PCTs still have a has merit view of 56.10%, most of whom hold that every technological development is made on the basis of scientific discovery because scientific discoveries always seek their usefulness, both for technological development and for other scientific uses.

On the third item on the interconnection of science and technology, as much as 39.02% PCTs has a realistic view that scientific research leads to practical application in technology and technological
development enhances the ability to conduct scientific research. However, more PCTs still have a has merit views of 48.78%, most of whom hold that science is the basis of all technological advances, although it is difficult to find examples of how technology can contribute to the development of science. Surprisingly, there were still many PCTs with a naïve view of 9.76%, who hold that science and technology are different, but both have a very close relationship and are difficult to explain separately. Although they realize that science and technology are interconnected with each other, they still think that technology is just a technology implementation. This perspective only sees that technology is a product of science, although in some scientific investigations, science requires technological help even in the early development of science [16]. It can be concluded that most PCTs have VNOST at has merit levels on aspects of science and technology relationships.

Based on the findings presented above, it can be concluded that most PCTs have views about the nature of science and technology that are still not fully appropriate with the general view of science, concepts, and the theory of science.

3.2. Conceptions about the context of Organic Light-Emitting Diodes (OLED) and the related chemistry contents

The data about PCTs’ conception on the OLED context and related chemistry content was collected by interviewing a few questions about related chemical content first, then continuing with questions related to the OLED context. The chemistry content in questions was about the ability of the electrolyte solution to conduct electrical current, the ratio of the electrical conductivity properties between the solution and the molten salt, the factors affecting the physical properties (melting point) of ionic compounds, the knowledge of ILs and their ability to conduct electrical current, knowledge of the causes of metal crystals can emit colour and technology utilizing the phenomenon, citing one example of the technology (in this case the Light-Emitting Diode, LED) and how it works. In addition, the questions also asked about the knowledge of organic compounds and structural influences on the nature of organic compounds, knowledge of organic compounds that have color and technology that utilize the phenomenon (in this case OLED).

The PCTs’ response in answering questions related to the chemical content associated with OLED is still mixed. In the electrolyte solution, which plays a role in conducting electric current is the presence of free-flowing ions, but there are PCTs that associate it with the electrolysis cell. In addition, there is still a confused PCTs in comparing the electrical conductivity between the solution and the molten salt. Almost all PCTs agree that what affects the physical properties (melting point) of ionic compounds is their structure from their salts. However, there are still many who still confuse what kind of salt structure has high melting point and which salt structure has low melting point.

All PCTs do not yet know that there is a salt that is in liquid room temperature (ILs) and some assume that ILs have weak electrical conductivity. Almost all PCTs know the mechanism of color emission in metal crystals, but are unable to mention the technology that utilizes the phenomenon (in this case the LED). Almost all PCTs do not know how the LED works. In addition, all PCTs know that structures have an effect on the nature of organic compounds, and know that there are some organic compounds that have color, but again all PCTs are unable to mention the technology utilizing the phenomenon (in this case OLED).

In the OLED context, the questions raised are about the OLED definition, the similarities and differences of LEDs and OLEDs, the characteristics of organic compounds in OLEDs, the mechanism of light emission on organic compounds, OLED device structure, OLED workings, and the role of ionic liquids in OLED. All PCTs do not know OLED definitions. After knowing the definition of OLED, almost some PCTs are able to mention the difference LED and OLED, ie in the semiconductor, but the knowledge of the equation is still not achieved. In the question of the characteristics of organic compounds in OLED, many PCTs respond that the characteristic is to have a benzene ring and there is a nitrogen element. Nearly all PCTs lack understanding of the mechanism of light emission in organic compounds, OLED device structure, OLED workings, and the role of ionic liquids in OLEDs.
They are also interviewed about their response to the importance of linking the OLED context in school chemistry, the most effective ways and media in helping OLED context learning and parts of the OLED context that requires media, and so on. All PCTs agree that linking the OLED context in school chemistry is important. Some PCTs assume that the most effective way of learning the OLED context is with problem-based learning. When they were asked to sort the most perceived media effectively, most responded that the most effective media sequences were interactive simulations, animations, analogies, and videos. The parts that require the media in the explanation are in the light-emitting mechanism part of the OLED, the role of ionic liquids compared with other electrolytes, etc.

Based on the results of PCTs conception interviews on the OLED context and related chemical content, it was found that PCTs still has a limited understanding of OLED and also shows that PCTs still has a fragmented understanding of chemistry concepts such as electrochemical, oxidation-reduction reactions, and the relation between chemical bonding to the physical properties.

4. Conclusion
Based on the findings, it can be concluded that generally PCTs have VNOST at has merit level. Meanwhile, according to interview results, PCTs still has a limited understanding about OLED and also shows that PCTs still have fragmented understanding of some chemistry concepts. To improve the PCTs’ VNOST and their conceptions of the context of OLED and the related chemistry contents, further explanation about science and technology and associate chemistry learning with related technology is needed. To find out how the views of those who choose option “none of the above options are fits with my views”, necessary also further research by using other methods.

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References
[1] OECD 2016 PISA 2015 Results (volume I) Excellence and Equity in Education (Paris: OECD Publishing) p 44
[2] Vesterinen V M 2012 Nature of Science for Chemistry Education (Helsinki: Academic Dissertation, University of Helsinki) p 1
[3] Lederman N G 2006 Nature of Science: Past, Present and Future (Mawah, NJ: Lawrence Erlbaum) chapter 28 p 831-835
[4] Lederman N G, Lederman J S and Antink A 2013 IJEMST. 1 p 138-147
[5] Tairab H H 2001 Res. Sci. Tech. Edu 19 p 235-250
[6] Tala S 2013 The Nature of Technology – Implication for Learning and Teaching ed Clough M P, Olson J K and Niedeshauzer (Rotterdam: Sense Publisher) chapter 4 pp 51-83
[7] Chamizo J A 2013 Found Chem. 15 p 157-170
[8] Hernani, Mudzakir A and Sumarna O 2016 JPll. 5 p 63-68
[9] Brennecke J F and Maginn E J 2001 AIChe Journal. 47 p 2384-2390
[10] Bybee R W, Powell J C and Ellis J D 1991 Sci. Educ. 75 p 143–155
[11] Jauhariansyah S, Mudzakir A and Widhiyanti T 2017 Proceedings International Conference On Mathematics and Science Education ed Abdullah A G, Nandiyyanto A B D, Riza L S, Riandi and Agustin R R (Bandung: Sekolah Pascasarjana Universitas Pendidikan Indonesia) p 774-782
[12] Tairab H H 1999 Res. Educ. 65 p 81–87
[13] Duit R, Gropengießer H, Kattmann U, Komorek M and Parchmann I 2012 The Model of Educational Reconstruction–A Framework for Improving Teaching and Learning Science (Rotterdam: Sense Publishers) p 13-37
[14] Aikenhead G S, Ryan A G and Fleming R W 1989 Views on Science-Technology Society (Saskatoon: Department of Curriculum Studies, University of Saskatchewan) p 1-116
[15] Vazquez-Alonso A and Manassero-Mas M 1999 Int. J. Sci. Educ. 21 p 231-247
[16] Gardner P L 1994 *Int. J. Tech. Des. Edu* 4 123-153