Students’ preconceptions of the context of magnetic media lubricants and the related chemical contents

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Abstract. This study aims to analyze students’ preconceptions regarding the context of magnetic media lubricants and chemical content related to the context, as the basis for didactic design development that can teach technological aspects in high school chemistry learning. Descriptive research methods are used in explaining the results of the research obtained. This study involved 40 students from one of the high schools in the city of Bandung. The preconception test questions are based on a magnetic media lubrication enrichment book that was previously developed by researchers, which contains the context of magnetic media lubricants with chemistry contents are transition metals, chemical bonds, and intermolecular forces. Student answers are analyzed using a frequency distribution to categorize the criteria of conceptual understanding of each question and the answers are analyzed for errors to show learning obstacles that might arise in learning. In general, the results show that students still have a limited understanding. Therefore, it is necessary for educators to develop a didactic design based on the findings of student learning obstacles so as to be able to integrate technology in science learning comprehensively and optimally.

1. Introduction
Technological developments that quickly have an impact on the education curriculum in Indonesia that require graduates to be able to use their understanding of concepts taught in certain contexts such as technology [1]. Technology is closely related to scientific literacy where the development of advanced technology is part of the context of scientific literacy so graduates who have good scientific literacy skills are one of the main goals that must be achieved [2][3].

But the current phenomenon, the younger generation tends to only act as consumers without wanting to know why and how the technology develops [4]. This happened one of them due to lack of technology involvement in science learning [5][6]. In addition, the low score of Indonesian students' scientific literacy scores at the nominal level shows that science learning is more demanding in memorizing the names of concepts or terms but cannot explain their meaning [7][8].

In an effort to overcome these problems, technological involvement is very important in science learning. Technology has a positive impact on science learning because it can encourage students to be more involved and motivate them to store more information [9]. In addition, technology can help make scientific content concrete and increase students' interest in science [10].
In supporting with technology in science learning, it has developed one form of learning in Science, Technology, and Society (STS). STS agreement for issues or problems that exist in the community related to science and technology, then seek solutions by technology. STS has been carried out by science education researchers. Some studies on STS learning have been shown to improve student understanding and student attitudes towards science [11][12]. However, in these studies, the technology presented was not very visible. In the learning that is carried out, it goes further to the problems posed in society. In addition, the technology presented in learning is not an updated technology, as is still the case in diesel engines or gliding vehicles.

One of the technologies that are being warmly discussed in and close to student life is the application of magnetic media ionic liquid lubricants [13]. Research related to magnetic media lubricants in the field of education has been carried regarding the development of magnetic media lubricant enrichment books in building chemical literacy of high school students. The results of the study show the potential of enrichment books in building students’ scientific literacy. However, this study still supports the students' independent learning of enrichment books developed, not yet leading to how the book was submitted by educators through the learning process. Therefore, there is a need for further research regarding this context in the form of design.

Research related to didactic design has been carried on the application of ionic liquids for SMK students. The results of the study show good potential in improving students' understanding. Based on this study, it is necessary to do the same research with the context and content of the latest context media lubricant technology, so that the design potential of the design is didactic in the context of the technology. One of the steps that need to be done in the near design research is analyzing students' preconceptions towards the analysis of magnetic media lubricant technology and chemical content related to the context which is used as a basis in didactic design development that can help develop technology in high school chemistry learning.

2. Methods
The method used is a descriptive method. The participants involved in this study were 40 high school students majoring in MIPA in one of the high schools in Bandung which were randomly selected from class X to XII. The preconception test consist of 17 questions were compiled based on the material in the sub-section of the chemical enrichment book about media magnetic lubricant context compiled by previous researchers, namely (1) Hardisk Drive System (2) Characteristics of Magnetic Media Lubricants, (3) Ionic Liquid Based Lubricants as Magnetic Media Lubricants Innovations, (4) Typical Characteristics of Ionic Liquids. In addition, chemical content related to this context is the chemical bonding of ionic compounds and the intermolecular forces and the transition metals chemistry. Each section is asked questions related to context and chemical content related to the context. This is done to determine the extent of the conceptions students have in understanding the context of magnetic media lubricants that will be used as a technological context in the didactic design that will be created. Student answers were analyzed for each question using frequency distribution based on the answer rubric and the four criteria for conceptual understanding namely understanding the concepts correctly (MB), understanding concepts but not convincing/sufficient (M), misconceptions (MSK), and not knowing the concept or did not answer (TM) [14][15]. The percentage of each the criteria obtained from:

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\text{\% the criteria} = \frac{\text{the number of students' answers according to criteria}}{\text{total students}} \times 100\%
\]

In addition, each student's answers are analyzed for errors to show learning obstacles that might arise in learning.

3. Result and Discussion
3.1. Analysis of students' preconceptions on Hard Disk Drive Systems
In the first sub-section on the system hard disk drive, there are six questions that are arranged relating to the context and chemical content related to the context, namely the nature of the transition group elements and the problems on the hard disk drive. The nature of the transition group element used is the determination of the magnetic properties of a metal based on the presence of unpaired electrons in the d-orbitals (Q1-Q2) and the determination of the contribution of both platter metals namely Co and Cr based on the physical properties of both (Q3). In addition, problems that arise in important components of hard disk drives such as corrosion (Q4), prevention methods (Q5), and the working principle of lubricants in overcoming these problems (Q6), are compiled in completing the hard disk drive systems sub-section. The results of the analysis of conceptual understanding criteria based on student answers to the system hard disk drive sub-sec are shown in table 1.

Table 1. Percentage of conceptual understanding criteria based on students' answers to the hard disk drive systems

| Questions | % The criteria of the conceptual understanding based on student answers |
|-----------|-----------------------------------------------------------------------|
|           |MB| M | MSK| TM| |
| Q1        |5 |87.5|7.5|0 |
| Q2        |40|27.5|20|12.5 |
| Q3        |32.5|50|10|7.5 |
| Q4        |62.5|37.5|0|0 |
| Q5        |40|12.5|42.5|5 |
| Q6        |55|17.5|10|17.5 |

Table 1 shows the percentage of conceptual understanding criteria related to the Haddisk Drive Systems sub-section. Most students have "understanding the concepts correctly/MB" criteria for understanding concepts in questions Q2, Q4, and Q5. However, in questions Q1 and Q5 the criteria for understanding are "sufficient/M" to be more dominant at 87.5%. Question Q1 deals with the definition of the magnetic properties of a metal, which is ferromagnetic, paramagnetic, and diamagnetic, and Q5 questions related to salt, one of the substances that accelerates the process of corrosion. For example, based on the results of student answers to question Q1, most students only define magnetic properties based on one theory only, namely magnetic pull strength. One of the answers of most students is "Ferromagnetic: objects drawn strong by magnets, for example: iron, steel, nickel, cobalt; paramagnetic: objects drawn weakly by a magnet, for example: platinum, aluminum, salt; diamagnetic: objects that are rejected or not attracted by a magnet, for example: tin, zinc, gold, bismuth". The answer is a general definition of magnetic properties but has not shown an answer in the chemical field. If you look at the literature in a chemistry textbook, the magnetic properties of a metal can be defined as follows: "Diamagnetics do not contain unpaired electrons in their d-orbitals or all electrons from the atoms that form them in pairs and are slightly rejected by the magnet. Paramagnetics contain unpaired electrons in their d-orbitals or atoms have one or more unpaired electrons and are attracted by a magnet. Ferromagnetic contains a lot of unpaired electrons in its d-orbitals and is attracted by magnets ".

By involving the concept of the existence of unpaired electrons in the d-orbitals provides an explanation of the microscopic level. This level is an abstract part but becomes a chemical domain that differentiates it from other disciplines. In addition, an explanation of microscopic levels can help students develop a deep understanding of certain concepts [16]. The right way to explain the third definition of magnetic properties is that educators need to provide data both images and videos that show the effect of the presence of unpaired electrons on the strength of the magnetic properties of metals. The strength of the attraction of the external magnetic field to the metal can be made a difference between the three traits, but by giving an image of the direction of the domain electron can provide a picture and a strong reason about the order of strength of the magnetic properties.

3.2. Analysis of students' preconceptions on the characteristics of magnetic media lubricants
In the second sub-section on the characterization of magnetic media lubricants, there are two questions relating to the context and chemical content related to the context that is the characteristics of lubricants which are good at working under certain conditions (Q7) and associated with the principle of intermolecular force in explaining (Q8). The results of the analysis of conceptual understanding criteria based on student answers to the characteristics of magnetic media lubricants are shown in table 2.

Table 2. Percentage of conceptual understanding criteria based on students’ answers to the characteristics of magnetic media lubricants

| Questions | % The criteria of the conceptual understanding based on student answers |
|-----------|---------------------------------------------------------------------|
| Q7        | MB: 32.5, M: 50, MSK: 10, TM: 7.5                                    |
| Q8        | MB: 35, M: 15, MSK: 15, TM: 35                                      |

Table 2 shows the percentage of conceptual understanding criteria based on student answers regarding the characteristics of magnetic media lubricants sub-section. As many as 50% of students have "sufficient/M" conceptual understanding criteria for Q5 questions. In increasing conceptual understanding of the question, educators need to determine the characteristics associated with lubricants on these requirements so as to enable students to get directed and precise. In addition, in Q8 question about intermolecular force in explaining lubricant characteristics, 35% of students did not give answers/TM. This is contrary to students do not understand the definition and strength of intermolecular forces in influencing the characteristics of a lubricant. To overcome this, educators need to provide the right picture such as the use of molymod, images, and videos because the intermolecular force is a concept that describes abstract.

3.3. Analysis of students' preconceptions on the ionic liquid based lubricants as innovations in magnetic media lubricants

In the third sub-section on ionic liquid based lubricants as an innovation in magnetic media lubricants, there are four questions relating to the context and chemical content related to the context, namely the definition of lubricants seen from the process of oil separation (Q9), differences in conventional lubricants and ionic liquid based lubricants (Q10), the contribution of ionic liquid based lubricants in energy-saving movements (Q11), and the advantages of ionic liquid based lubricants compared to conventional lubricants (Q12). The results of the analysis of conceptual understanding criteria based on student answers to the ionic liquid based lubricant as an innovation for magnetic media lubricants sub-section are shown in Table 3.

Table 3. Percentage of conceptual understanding criteria based on students' answers to ionic liquid based lubricant as an innovation for magnetic media lubricants

| Questions | % The criteria of the conceptual understanding based on student answers |
|-----------|---------------------------------------------------------------------|
| Q9        | MB: 22.5, M: 55, MSK: 5, TM: 17.5                                    |
| Q10       | MB: 7.5, M: 82.5, MSK: 5, TM: 5                                      |
| Q11       | MB: 42.5, M: 50, MSK: 0, TM: 7.5                                     |
| Q12       | MB: 42.5, M: 37.5, MSK: 5, TM: 15                                     |

Table 3 shows the percentage of conceptual understanding criteria based on students' answers regarding ionic liquid based lubricant sub-sections as an innovation for magnetic media lubricants. Based on table 3, Q12 questions most students have “understanding the concepts correctly/MB” conceptual understanding criteria, and in questions Q9, Q10 and Q11 are dominated by students with sufficient conceptual understanding criteria. However, as many as 17.5% in the Q9 questions students did not answer/TM the question.
In improving students' conceptual understanding of "sufficient/M" to be "understanding the concepts correctly/MB" in the ionic liquid based lubricant as an innovation of magnetic media lubricants sub-section, educators need to provide temperature difference data so that they can direct students to the expected answers. In addition, media in the form of images or videos related to the process of separating petroleum fraction can be used as well as needing to provide illustrations in the form of images or videos related to the molecular structure of each lubricant so that students can understand precisely the differences between the two types of lubricants. In addition, a large percentage TM of Q9 questions indicate that students do not understand the separation of petroleum fraction using multilevel distillation. This can be overcome by giving a re-explanation of the separation process accompanied by illustrations both images and videos of the process of separating petroleum fractions.

3.4. Analysis of students' preconceptions on typical characteristics of ionic liquids

In the fourth section on the typical characteristics of ionic liquids, there are five questions relating to the context and chemical content related to the context, namely the definition of ionic liquids (Q13), differences in ionic liquids with other ion compounds (ex. NaCl) (Q14), characteristic of liquids ionic based on its molecular structure (Q15), the equation of the reaction that occurs in the process of making ionic liquids (Q16), and the magnetic properties of ionic liquids [bmim] FeCl₄ (Q17). The results of the analysis of conceptual understanding criteria based on student answers to the typical characteristics of ionic liquids sub-sections are shown in Table 4.

Table 4. Percentage of conceptual understanding criteria based on students' answers to the typical characteristics of ionic liquids

| Questions | % The criteria of the conceptual understanding based on student answers |
|-----------|------------------------------------------------------------------------|
|           | MB | M | MSK | TM |
| Q13       | 27.5 | 65 | 5 | 2.5 |
| Q14       | 7.5 | 52.5 | 22.5 | 17.5 |
| Q15       | 32.5 | 20 | 13.75 | 33.75 |
| Q16       | 17.5 | 7.5 | 0 | 75 |
| Q17       | 0 | 40 | 0 | 60 |

Table 4 shows the percentage of conceptual understanding criteria based on students' answers related to the typical characteristics of ionic liquids sub-section. In questions Q13 and Q14 most students have sufficient conceptual understanding criteria. However, in questions Q15, Q16, and Q17 most students do not give answers.

In improving students' conceptual understanding of "sufficient/M" to be "understanding the concepts correctly/MB" in the typical characteristics of ionic liquids sub-section, educators need to provide a re-explanation regarding ionic bonds and provide an illustration of the molecular structure of one ionic liquid. In addition, educators need to emphasize and direct students to the important things in the illustrations given so that students can easily interpret the differences between ionic liquids and other ionic compounds.

In questions Q15, Q16, and Q17, most students do not give answers/TM. This is probably due to the lack of students' ability to express data making it difficult for students to answer questions about the difference in melting points between ionic liquids and other ionic compounds as the typical characteristic of ionic liquids. The term unexplained and new of ionic liquids for student makes students think difficult so most students don't give answers. When viewed from the preconception questions given, there is already supporting data in answering these questions as given the name of the actual compound, namely 1-butyl-3-methylimidazolium iron (III) chloride is [bmim]FeCl₄. In addition, magnetic susceptibility value data is given to facilitate students in answering the magnetic properties of ionic liquid [bmim]FeCl₄. However, the supporting data is still lacking in demanding students to understand the typical characteristics of ionic liquids. This is a challenge for educators because of the lack of students'
ability to process data. To overcome this, educators need to provide systematic explanations and are supported by precise illustrations of images, videos and other data.

4. Conclusion
Based on the findings, it can be concluded that most students have difficulty in answering preconception test questions related to the context of magnetic media lubricants and chemical content related to the context. Students have difficulty interpreting the data given in the form of both illustration and table illustrations so that they have not been able to analyze properly the contribution of Co and Cr metals as multilayer magnetic constituents, the influence of intermolecular forces on the characteristics of magnetic lubricants, and the influence of molecular structure on typical characteristics of liquids ionic. In addition, students have a lack of understanding of the concepts of intermolecular force, chemical bonds, and magnetic properties.

These results reveal that students have limited conceptual understanding and need to be improved so it is important for educators to develop didactic designs based on the students' preconceptions findings that can integrate science and technology in science learning. In addition, didactic designs that are arranged must be able to synergize with aspects of content in accordance with the demands of the applicable curriculum, as well as aspects of the context charged by technology that are close to the lives of students.

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