Identification of senior high school students’ preconception on artificial muscle context in chemistry learning

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Abstract. This research aims to identify students’ preconceptions on artificial muscles context as a basis for developing a didactic design in artificial muscle learning, related to chemical contents studied in secondary school. This study employed a descriptive method that was presented quantitatively and qualitatively. The instrument used in this study was a test in the form of essay questions consisted of 7 discourses about artificial muscles. The participants of this study were 25 students from a secondary school in Bandung, West Java. The results of data analysis indicated that 76% of students fell in the category of “low understanding”. The analysis of students’ preconception was used and implemented in the development of a didactic design aiming at connecting artificial muscle context with the application of science and technology in chemistry learning at secondary schools.

1. Introduction

Chemistry is part of science that study how matter in nature change from one form to another with certain properties [1]. Chemistry is often regarded as a difficult subject by students in Senior High School [2, 3] and some students even find it unattractive and not important [4]. In the learning process, especially science, students are required to be able to understand and appreciate how a concept is obtained, connecting one concept with another concept and using other scientific concepts to support certain scientific concepts [5].

Each student has different initial concepts (preconceptions) that they carry as knowledge. This preconception is built by students when they get new information. When students follow the learning process and accept new concepts, they will try to associate the new concept with the concepts they have had before. If students do not succeed in making the right relationship between the concepts they have and the new information provided by the educator, the wrong understanding will be formed [6]. The result is that students will retain their understanding of the original concept and put their new concepts in their cognitive structure separately [7].

The causes of the misconception in students include the students themselves, educators, textbooks, contexts and the learning methods. In addition, there are characteristics of the subject matter that cause students difficulties in interpreting and creating their own concepts [8]. Thus the understanding of students in a concept may be accompanied by an incomplete understanding on a concept.

The material used in this study is the artificial muscle context. Artificial muscle context was chosen because it is one of application context of the latest science and technology that is developing and is closely related to chemical content in school. Artificial muscle is an actuator which is analogous to the
muscle skeleton (biological/natural muscle). Like natural muscle, each artificial muscle is characterized by its ability to contract which is a response to a stimulus, both in a way chemical or physical. The artificial muscle context is related to chemical material in schools such as polymeric materials, covalent bonds, electrolytes and hydrolysis. The existence of misconceptions in chemistry lessons can have a fatal impact because in general, chemical concepts are taught from simple concepts to complex concepts. So, if the concept is easy for students to have the wrong concept, the students will fell more difficult to understand complex chemical concepts.

Analysis students’ difficult about artificial muscle context is needed to produce a learning design that can eliminate previous conceptions and replace them with an acceptable scientific view [3, 9]. Therefore, it is important to analyze students’ difficult in interpreting chemical concepts in the artificial muscle context. Based on this, this study aims to analyze the students’ difficulties to connect the artificial muscle context as the application of science and technology to learning chemistry in school.

2. Methods
This research was conducted in one of the Senior High Schools in Bandung City. The subjects in this study were 25 students of class XI MIPA 1. This study used a test instrument in the form of an essay test to determine the conceptions of students. The essay test is compiled based on the curriculum analysis used in the school related to basic competencies and indicator form, and the material has relevance to the artificial muscle context. The essay test used consisted of 7 discourses. To determine the validity or suitability of the essay test, a suitability test is carried out by asking for consideration from experts in the field being measured. After getting advice and input from experts, then revisions are made to improvements to the essay test to be used. This study uses descriptive methods which are presented quantitatively and qualitatively. Qualitative analysis is carried out to find out the students’ difficulty part about the artificial muscles context. Whereas for quantitative analysis is done by assessing the students’ test results using the assessment rubric, so that data will be obtained in the form of scores/values obtained by each students. Each score obtained by each students will be grouped according to five appropriate categories, namely: very good, good, fair, low and very low.

3. Result and Discussion
This study examined students’ difficulties in understanding artificial muscles context. The essay test used consisted of 7 discourses based on enrichment books regarding the artificial muscles context. The results of percentage of students’ understanding are presented in Table 1. After analyzing the students’ understanding concept for each question, an analysis of the students’ conceptual understanding of the artificial muscle context was carried out. The results of analyzing students’ understanding concept about artificial muscle context are presented in table 2.

Based on Table 1, it was found that most of the students about 76% had low understanding, 12% had a fair understanding and 12% of students had very low understanding. This shows that most students have experience low concept in understanding about the artificial muscles context. This is because students found it difficult to connect the chemical concept of artificial muscle context. Therefore, the difficulties in this section will be discussed in the next sub topic.

| No. | Essay Test Question for Every Discourse | Student Conception (%) |
|-----|----------------------------------------|-------------------------|
|     | D1: What is the meaning of polymer?     | Good: 20   | Enough: 36 | Low: 44 |
|     | D2: What examples of objects are mostly applied by polymers based on their classification? |                      |
|     | D2: Elastomer is often referred to as rubber. What is the meaning of elastomer? | Good: 20   | Enough: 40 | Low: 40 |
|     | D2: Electrolytes can be acids, bases and salts. In your opinion, what is electrolyte treated? | Good: 0    | Enough: 28 | Low: 72 |
No. | Essay Test Question for Every Discourse | Student Conception (%) | Good | Enough | Low |
--- | --- | --- | --- | --- | --- |
5. | Explain what is the difference between electronic PEA and ionic PEA. | 0 | 92 | 8 |
6. | In your opinion, what counts with conjugated double bonds? | 32 | 16 | 52 |
7. | In your opinion, what is dopant? | 20 | 24 | 56 |
8. | In your opinion, why can polymers with conjugate bonds have conductive properties when they are electrified? | 16 | 20 | 64 |
9. | What is a heterocyclic ring? | 12 | 28 | 60 |
10. | In your opinion, why do polymers that have heterocyclic rings even though they do not have conjugate bonds can still conduct electricity? | 12 | 4 | 84 |
11. | Explain what is meant by hydrolysis? | 48 | 8 | 44 |
12. | Mention three salt compounds that can undergo hydrolysis | 32 | 28 | 40 |
13. | Explain why the ionic liquid at room temperature is liquid while the salt is a solid | 12 | 12 | 76 |
14. | Is it possible for a salt to melt at a low temperature or at room temperature? | 0 | 4 | 96 |
15. | What do you think is the difference between the structure of NaCl salt and ionic liquid (BMIm)NH\(_2\)) at room temperature? | 0 | 4 | 96 |
16. | In your opinion, which has a relatively lower melting point? | 0 | 36 | 64 |
17. | Explain what is meant by the electrostatic force | 28 | 0 | 72 |
18. | Explain how the process of electrostatic force on the mechanism of artificial ionic muscles? | 4 | 16 | 80 |
19. | Try to mention the application of PEA as an artificial muscle that can be used by humans in the future. | 4 | 16 | 80 |
20. | In your opinion, is the application of polymer materials as artificial muscles very useful? | 4 | 20 | 76 |

### Table 2. Percentage of Students’s Understanding Concept About Artificial Muscle Context

| Criteria       | Score | Number of Students | Percentage (%) |
|----------------|-------|--------------------|----------------|
| Very Good      | 80-100|                    |                |
| Good           | 61-80 |                    |                |
| Fair           | 41-60 | 3                  | 12             |
| Low            | 21-40 | 19                 | 76             |
| Very Low       | 1-20  | 3                  | 12             |

Analysis of students’ responses in the essay test along with the analysis of students’ obstacle were tabulated in Table 3. The test evaluated students’ understanding on the difference between electronic EAP and ionic EAP, the difference forms of ionic liquids and salts at room temperature, melting point of salt and ionic liquids, electrostatic force’s effect on mechanism of ionic artificial movement, differences in the workings of electronic PEA and ionic PEA and the development of artificial muscles in the future in various fields.

### Table 3. The Analysis Students’ Answer and Students’ Obstacle

| No | Question                  | Analysis of Students’s Answer | Analysis Obstacle Learning |
|----|---------------------------|-------------------------------|----------------------------|
| 1  | What is polymers?         | 44% of students could not define polymers. Some students define polymers only based on the Greek language “poly” and “mer”, which is equal 36%. | Most students had difficulties in defining the polymer. |
| No | Question                                                                 | Analysis of Students’s Answer                                                                 | Analysis Obstacle Learning                                                                 |
|----|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| 2  | Give the classifications of polymers?                                    | Most students didn’t understand the classification of polymers, which is 92% of students could only classify polymers based on synthetic and natural polymers. | Most students didn’t have enough knowledge in providing polymer example based on their classification. |
| 3  | Elastomer is often referred to as rubber. In your opinion, what is the meaning of elastomer? | Students didn’t understand the notion of elastomer which is equal to 40%. Some students define elastomer only by defining elastomer often called rubber which is an example of polymer, | Most students couldn’t define elastomer correctly because conventional chemistry teaching is mostly centered on educators where so far students learn to use memorization methods without any emphasis on constructivist approaches. |
| 4  | Electrolytes can be acids, bases and salts. In your opinion, what is electrolyte solutions? | Most students didn’t understand the notion of electrolytes which is equal to 72%. Some students defined electrolytes only by defining electrolytes as substances containing electrical ions, which is 28% | Most students cannot define electrolytes correctly due to conventional chemistry teaching which is mostly centered on educators where students learn to use memorization methods without any emphasis on constructivist approaches. |
| 5  | Explain the differences between electronic PEA and ionic PEA.            | Most students weren’t right in answering the difference between electronic PEA and ionic PEA which is equal to 92%. Students only distinguish the two based on the electric field (electronic PEA) and ion diffusion (ionic PEA). | Most students answer incorrectly because they do not have an adequate understanding of electroactive polymers as ingredients for artificial muscles. |
| 6  | What is conjugated double bonds?                                        | Students didn’t answer the notion of conjugated double bonds correctly at 52%. Then 16% of students answered incorrectly namely that conjugated double bonds are bound which contain cis and trans conformations. | Students had difficulty in defining conjugated double bonds. This is because some students do not have an adequate understanding of the characteristics of a polymer to be conductive. |
| 7  | What is dopant?                                                         | As many as 56% of students found it difficult to define dopant. Then 24% of students answered incorrectly in defining dopants, namely as substances that increase electron transfer. | Students didn’t have an adequate understanding of the characteristics of a polymer to be conductive. |
| 8  | Why polymers with conjugate bonds have conductive properties when they are electrified? | As many as 64% of students found it difficult to give reasons why polymers with conjugated bonds can have conductive properties when electrified. Then 20% of students answer because the electrons can move. | Students had difficulty understanding polymers can be conductive if they have contracted double bonds. |
| 10 | Why polymers that have heterocyclic rings with no conjugate bonds can still conduct electricity? | As many as 84% of students could answer correctly why polymers that have heterocyclic rings that do not have conjugate bonds can still conduct electricity. Then 4% of the students were not right in answering that is because the polymer was added by dopants. | Students had difficulty understanding polymer can be conductive if it has a heterocyclic ring. |
| 11 | What is hydrolysis?                                                     | 8% of students answered incorrectly. Some students stated that hydrolysis is a reaction that breaks water. | Most students had been able to explain the meaning of hydrolysis correctly. The causes of difficulties and misunderstandings were influenced by conventional chemistry teaching which is mostly centered on educators where students learn to use the memorization method as a sign of an emphasis on a constructivist approach. |
| 12 | Mention three salt compounds that can undergo hydrolysis              | Students couldn’t give examples of salt compounds that can undergo hydrolysis correctly that is equal to 40%. Then 28% of students answered incorrectly in giving several examples of salt compounds undergoing hydrolysis. | Most students had difficulty in answering this question, because students do not have enough basic knowledge about the benefits of... |
| 13 | Mention the application of PEA as an artificial muscle that can be used by humans in the future. | As many as 80% of students could not mention the application of PEA as an artificial muscle that can be used by humans in the future. Then, 16% of students answered incorrectly, namely as a tool to make it easier... | Most students had difficulty in answering this question, because students do not have enough basic knowledge about the benefits of... |
No. Question Analysis of Students’s Answer Analysis Obstacle Learning

20 Is the application of polymer materials as artificial muscles very useful? As many as 76% of students could not explain the benefits of artificial muscles. Then, 20% of students answered the polymer as artificial muscle is very useful for reasons that are less precise. PEA as an artificial muscle for humans. Most students had enough basic knowledge about the development of artificial muscles from time to time.

4. Conclusion
Based on the results of this study, it can be concluded that students have quite number misconceptions on the artificial muscle context. Students have difficulty in answering the questions given because they did not have sufficient basic understanding possibly due to conventional teaching using memorization methods without any emphasis on constructivist approaches. In addition, students also have difficulty in relating the chemical concepts they have with new concepts about the artificial muscle context.

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