Description of learning difficulties on atomic structure and periodic table topics of tenth grade students in SMAN 7 Padang

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Abstract. This descriptive research was done on atomic structure and periodic table topics in SMAN 7 Padang. On these topics, students had difficulties on achieving learning goals where only 38% students could achieve the minimum defined criteria. This research aims to determine percentage of learning difficulties in all learning indicators and find factors that cause learning difficulties. 57 tenth grade students as research sample were obtained through cluster sampling technique. Research instruments used were diagnostic test and questionnaire and data were then analyzed descriptively. Analysis showed that learning difficulties were 91.2%, 13.2%, 88.3%, 51.5%, 70%, 64%, 84%, 84%, and 74.9% in the indicator of describing subatomic particles and their discovery; determining atomic number and mass number of elements and isotopes; describing atomic model according to Dalton, Thomson, Rutherford, Bohr, and wave mechanics; explaining electron configuration and orbital diagrams; determining quantum number and orbital shape; describing development of periodic system; modern periodic system; periods and groups in periodic table; and periodic trends of elements respectively. Students’ learning difficulties were influenced by school factors including teaching methods 35.8%, curriculum 47.5%, teacher relation with students 49.1 %, relation among students 41.7%, time and school discipline 33.3%, teaching tools 39.4% and school building condition 17.7%.

1. Introduction
Atomic structure and periodic table are topics studied in grade X senior high school. Based on syllabus of curriculum 2013 revision, these topics consist of concepts including subatomic particles, atomic number and mass number, isotope, development of atomic model, electron configuration and orbital diagram, quantum number and shape of orbital, relationships of electron configuration and periodic table, and periodic table of elements and periodic trends. Data obtained in SMAN 7 shows that 62% students got score below the minimum defined criteria implying that most students had difficulties in understanding these topics. Learning methods used in these topics are lecture and discussion while instructional media used are textbook, PowerPoint slide and periodic table.

Abdurrahman explained that students can have academic learning difficulties in addition to their developmental issues [1]. Student is alleged to have learning difficulties if she/he cannot achieve qualification level of certain learning outcomes [2]. Several attempts can be done to identify students' difficulties in learning concepts. One of them is by conducting diagnostic tests regarding the concepts
Diagnostic test is a test designed to individually test and identify weaknesses in learning process [3]. Diagnostic test has several types including diagnostic tests with multiple-choice followed by reasons (two-tier multiple-choice diagnostic instrument). Two-tier multiple-choice diagnostic instrument consists of two parts. The first part consists of questions with many optional answers (usually four to five options) while the second part is where student gives reasons for his/her answer [4].

To identify in what learning indicators students have learning difficulties, authors gave diagnostic test to students. To get additional information, factors that affect students’ learning difficulties were also studied.

2. Methodology
This research is descriptive in nature. Descriptive research is a research method that portrays the object as it is [5]. Researchers try to describe events and incidents that become the center of attention without giving special treatment to the event [6]. Population of this study is all of 10th grade students in SMAN 7 Padang dispersed in six classes. Cluster sampling was conducted and X MIPA 2 and X MIPA 6 with 57 total number of students were determined to be research sample.

Instrument used in this study was a diagnostic test sheet in the form of objective with reasons. Questions were made accordingly to nine learning indicators of atomic structure and periodic table topics demanded by curriculum 2013. They are 1) Describing subatomic particles and their discovery, 2) Determining atomic number and mass number and isotopes of an element associated with its subatomic particle, 3) Describing atomic model of Dalton, Thomson, Rutherford, Bohr and wave mechanics, 4) Explaining the rules of writing electron configuration and orbital diagram 5) Determining quantum number and shape of orbital, 6) Describing the development of periodic system, 7) Explaining modern periodic system, 8) Determining period and group in periodic table based on electron configuration, 9) Analyzing periodic properties of elements (atomic radius, ionization energy, electron affinity, and electronegativity). Furthermore, analysis on validity, reliability, discriminating index, and difficulty index of the test was taken and 22 questions were considered to be included in the test.

Students’ answers were group into four categories called 1) Understand; when chosen answer and the explanation are correct, 2) Misconception when chosen answer is correct but the explanation is false, 3) Guess when chosen answer is false, but the explanation is correct, and 4) Do not understand when both chosen answer and explanation are false. The three last categories are perceived as learning difficulties [7].

Data obtained with diagnostic test were analyzed with percentage technique. Percentage of students’ learning difficulties per learning indicator is obtained with formula as follows.

$$P = \frac{\text{Total score}}{\text{Maximum Score}} \times 100\%$$  

(1)

$$\% K = 100\% - P$$

(2)

Note:
P = Percentage of students who do not have learning difficulties on each item.

% K = Percentage of students who have learning difficulties on each item [8].

Data is then interpreted based on criteria shown in Table 1 [9].

| Criteria         | Percentage (%) |
|------------------|----------------|
| Very high        | 81-100%        |
| High             | 61-80%         |
| Moderately high  | 41-60%         |
| Low              | 21-40%         |
| Very low         | 0-20%          |
As additional information, closed ended questionnaires were distributed to students in order to determine factors that contribute to students’ learning difficulties. These contributing factors were determined with percentage technique using the following formula [10].

\[ P = \frac{\Sigma F}{\Sigma N} \]  

(3)

Note:
- \( P \) = Percentage
- \( \Sigma F \) = Respondents answer score
- \( \Sigma N \) = Total Score

3. Result and Discussion

3.1. Learning difficulties

Based on result of research conducted on May 5th - 10th, 2017, we can identify learning difficulties on atomic structure and periodic table topics experienced by students in SMAN 7 Padang. These topics consist of nine learning indicators. Description of learning difficulties in those learning indicators is shown in Table 2.

Learning objective for indicator 1 is students are able to determine subatomic particles based on their discovery process appropriately. Indicator one was tested with two questions. In question one, students assumed that atomic nuclei have negative charge. In question two, students answered that cathode rays are positively charged particles called protons. Only 8.77% students understood indicator one. On the other hand 91.2% students had learning difficulties contributed from having misconception 0.9%, guessing 0.9%, and do not understand 89.5%.

| Learning indicator | Category of students’ answer per indicator | Learning difficulties per learning indicator (M+G+DU) | Category |
|--------------------|-------------------------------------------|-----------------------------------------------------|----------|
| 1                  | Understand (U) 8.77%                      | Have misconception (M) 0.9% | 91.2% | Very high |
| 2                  | 86.9%                                    | 1.75%            | 11.4% | Low |
| 3                  | 13.7%                                    | 2.46%            | 81.4% | Very high |
| 4                  | 49.1%                                    | 3.5%             | 47.34% | Moderately high |
| 5                  | 59.6%                                    | -                | 70%   | High |
| 6                  | 35.9%                                    | -                | 64%   | High |
| 7                  | 8.7%                                     | -                | 84%   | Very high |
| 8                  | 19.3%                                    | -                | 75.4% | Very high |
| 9                  | 25%                                      | -                | 69.29%| High |

Indicator 2 consists of two learning objectives 1) students can properly determine atomic number and mass number of atoms / elements in the periodic table and 2) students can correctly determine the isotopes of atom when atomic number and mass number are given. Students with learning difficulties amounted to 13.2% contributed from having misconceptions 1.75% and do not understand 11.4%. Students assumed that isotopes are atoms of the same element that have the same mass number.

Learning objective for indicator 3 is students are able to differentiate atomic theory according to Dalton, Thomson, Rutherford, Bohr, and wave mechanics by using model correctly. Students with learning difficulties amounted to 88.3%. This number is contributed from having misconceptions 2.46%, guessing 4.4% and do not understand 81.4%. This indicator was tested with 5 questions (question 5-9). In question 5 students responded that the weakness of Dalton atomic theory is that it cannot explain positively and negatively charged components of atom. In question 6, students chose
option that provided answer to Thomson atomic model as if atom consists of a positively charged nucleus and almost the entire mass of the atom locates at the center of atom. Atom according to Thomson consists of positive charges, which are assumed to be evenly distributed throughout the atom, and negative charges imbedded in the atom like plums in a pudding [11]. The previous statement is what Rutherford stated about the atom. Weakness of Rutherford atomic theory was tested with Question 7. Learning difficulty on this concept is students thought that electron moves around the smallest orbital. Question 8 tested Bohr atomic theory and students assumed that atoms and neutrons move around on a track called orbit. Atomic theory of wave mechanics was tested with Question 9. Learning difficulty found is students tended to choose the wrong answer. They thought electrons stationary move around nucleus on orbit with certain energy level.

Learning objective for indicator 4 is students are able to write electron configuration and orbital diagram accordingly. On this indicator 49.1% students achieved learning objectives while students who had learning difficulties were guessing 3.5% and do not understand 47.34%. Learning difficulties found are students chose wrong option that provided wrong electron configuration.

Indicator 5 consists of two learning objectives namely 1) students can determine principal, azimuth, magnetic quantum number and spin of electron based on atomic number of an element properly 2) students can determine the shape of orbital using model properly. 70% students did not understand this indicator. They could not determine each quantum number neither determine the shape of d orbital.

Learning objective for indicator 6 is students are able to distinguish the development of periodic system from metals and non-metals category, triad Dobereiner, Octave Newland law to Mendeleev periodic system. 64% students did not understand this indicator which was tested with four questions. Students were incorrectly name hydrogen, nitrogen, and carbon as metal elements. They also wrote atomic mass of Na as 22.99 without calculating the mean of atomic mass of Lithium and Potassium as what Dobereiner did to find his triad [12]. Students could not categorize elements with Octave Newland system, as students could not choose element that has similarities with Mg or Li [13]. In the last question, students could not determine prominent of Mendeleev periodic system. Instead they chose weakness of Mendeleev periodic system.

Learning objective for indicator 7 is students are able to explain modern periodic system properly. 84% students did not understand this indicator. Learning difficulty found is students chose wrong electron configuration for atom V as 1s\(^2\) 2s\(^2\) 2p\(^6\) 3s\(^2\) 3p\(^6\) 4s\(^2\) 4p\(^3\). Students did not understand the rules of electron configuration according to Aufbau principle, especially when involving transition elements.

Learning objective for indicator 8 is students can determine period and group in periodic table based on electron configuration correctly. 75.4% students did not understand this indicator. They incorrectly located element with electron configuration of 1s\(^2\) 2s\(^2\) 2p\(^6\) 3s\(^2\) 3p\(^2\) at group IIIA yet period 3.

Learning objective for indicator 9 is students are able to analyze periodic trends of elements (atomic radius, ionization energy, electron affinity, and electronegativity) within a group or period correctly. 74.99% students had learning difficulties contributed from guessing 5.7% and do not understand 69.29%. Learning difficulty found is students could not analyze trends of ionization energy and electron affinity within a group or a period. They chose atom with the biggest atomic number within a group as one that has the largest ionization energy. Students knew that F is atom having the biggest electron affinity but did not give reasons why. Furthermore, students assumed that atomic radius of atom within a period gets bigger as atomic number gets increase. They also thought that the easiest element to attract electrons is element with small electronegativity while in fact it is on the other way around.

3.2. Contributing Factors to Students’ Learning Difficulties.

Questionnaires were distributed to students in order to get external factors that cause learning difficulties. The result is shown in Table 3.
Table 3. Contributing Factors to Students’ Learning Difficulties.

| Indicator               | Sub Indicator                  | % Sub Indicator |
|-------------------------|--------------------------------|-----------------|
| School Factors          | Teaching Methods               | 35.8%           |
|                         | Curriculum                     | 47.5%           |
|                         | Relations between teacher and students | 49.1% |
|                         | Relations of among students    | 41.7%           |
|                         | Time and disciplined school    | 33.3%           |
|                         | Teaching equipment             | 39.4%           |
|                         | Building Condition             | 17.7%           |

As seen in Table 3, there are several factors from school that contribute to students learning difficulties. The school factors include methods of teaching as much as 35.8%, curriculum 47.5%, teacher relationship with students 49.1%, student relationship with each other 41.7%, time and school discipline 33.3%, teaching tools 39.4%, as well as the condition of school buildings 17.7%.

Method of teaching is ways teacher uses to convey lesson to students and thus achieve learning objectives. It this case 35.8% students said that teacher conveys concepts of atomic structure and periodic table less clearly and attractively. According to Dalyono [14] the selection of teaching methods should be adapted to conditions of students, school, and learning needs so that learning process can be done properly and thus contributes to the success of learning. Based on research questionnaire, 51.7% students considered atomic structure and periodic table as difficult topics. Besides, time provided to these topics is not sufficient. Therefore, these topics brings learning difficulties on students [14].

Relationship between student and teachers at schools affected as much as 49.1%. In this case teacher does not give opportunity for students to ask questions when they do not understand. Therefore students are less motivated and active in learning as demanded by curriculum 2013. In addition, the relationship among students has an effect on students’ learning success. Based on research questionnaire, 45% students were still misbehave and unsupportive to learning process. Bad relationship among students gives a negative impact on learning process. The absence of favourable attitudes among friends will interfere learning process.

Good school discipline and timing make children better. 3.3% students answered that they are less eager to go to school in the morning. 66.7% answered that learning early in the morning is better than studying in the daytime / evening. Furthermore, insufficiency of teaching tools creates unattractive learning [15]. In this case, learning tool in schools has an influence of about 39.4% showing that school does not have sufficient learning tools. There is still a lack of LCD, computers, and the Internet as well as the completeness of textbook or literature in the library. Next, condition of school buildings can support student learning. But it can also inhibit student learning. In this case building conditions in SMAN 7 Padang affected of about 17.7% meaning that most of building condition is good enough. It can be seen from good lights and air vents in class, good arrangement of tables and chairs, and adequate lighting in classrooms at the time of learning. Appropriate building helps students concentrate in learning [16].

4. Conclusion
10th grade students in SMAN 7 Padang had learning difficulties on atomic structure and periodic table topics. The level of difficulty experienced by students in each learning indicator is as follows.
1. Explaining subatomic particles and discovery process as much as 91.2% with high category.
2. Determining atomic number, mass number and isotopes of an element associated with the subatomic particles as much as 13.2% with very low category.
3. Explaining and portraying atomic model of Dalton, Thomson, Rutherford, Bohr and wave mechanics as much as 88.3% with very high category.
4. Explaining the rules of writing the electron configuration and orbital diagram as much as 51% with moderately high category.
5. Determining quantum number and shape of orbital as much as 70% with high category.
6. Describing development of periodic system as much as 64% with high category.
7. Explaining modern periodic system as much as 84% with very high category.
8. Determining period and group in the periodic table based on electron configuration as much as 81% with very high category.
9. Explaining periodic trends of elements (atomic radius, ionization energy, electron affinity, and electronegativity) as much as 74.99% with high category.

Factors that cause students' learning difficulties from school include teaching methods 35.8%, curriculum 47.5%, teacher relationship with students 49.1%, relationship among students 41.7%, time and school discipline 33.3%, teaching tool 39.4%, and condition of school buildings 17.7%.

**Limitation**
This descriptive research used instruments in the form of objective with reasons. Analysis of students’ answers may not be perfectly done as essay could have bias.

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