Wright-Map to Analyze Students' Abilities on Chemical Bond Test

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Abstract. The implementation of the evaluation of learning outcomes for students allows the emergence of biases that can cause students' abilities to not be depicted properly. This study aims to determine the ability of students based on the evaluation test of chemistry learning in high school. The research subjects involved 41 students. Data analysis using Wright Map on Rasch modelling based on chemical bond indicators such as 1) the process of forming ionic and covalent bonds, 2) differences in ionic and covalent bonds from physical and chemical properties, 3) analyzing the type of chemical bonds formed, and 4) determination of the shape of the molecule. Based on the results of the Wright Map, the percentage of students' abilities as much as 2% are in the high, 78% are in the medium, and 8% are in the low and very low categories. Overall, students have difficulty analyzing the type of chemical bond formed and the shape of the molecule. By using the Wright Map, the actual abilities of students can be seen clearly and accurately. This is very helpful for teachers to classify students whose scores are still below the average so that a corrective test can be done.

Keywords: Chemical bond test, student ability, wright-map

1 Introduction

In the world of education, the majority of measurement models use classical test theory. In classical test theory, two theoretical constructs can be observed through the observed score and cannot be observed. The observed score is obtained from the actual score and error. The actual score is the average score obtained from the test results independently and carried out repeatedly. The actual score can be used as an appropriate measure if it is accompanied by validity and reliability. This classical theoretical approach has several weaknesses, including 1) the statistics on the test items depend on the characteristics of the subjects being tested, 2) the ability of the test takers is very dependent on the test items being tested, 3) the standard error in the score estimator applies to all test takers, 4) the information presented is limited to correct or incorrect answers, 5) does not pay attention to the pattern of test takers' answers, and 6) the assumptions of parallel tests are difficult to fulfil. [1]–[4]. With these weaknesses, a better measurement analysis was found, namely the Rasch modelling analysis.

Rasch modelling is very different from classical test theory. In the Rasch model, measurements can be made at the item level of questions and persons or respondents. Rasch is also a model that has a high probability of responding to items or personal responses [5]. In Rasch, the implementation model is presented in three forms, namely, dichotomy, polytomy and PCM [6]. The Wright-Map is one of the role models in the measurement of Rasch analysis which aims to identify the existence of a test item or person from the test respondent which is described comprehensively, measured by constructs and meaningful context [7], [8]. Measurements on the Wright Map can reach all levels of respondents' abilities (high to low) as well as the level of difficulty of the questions (easy to difficult) [9], [10]. The Wright-Map analysis states that the higher the cognitive process possessed by students, the quality of the item question must have a higher level of difficulty. This is because the quality of the item questions is directly proportional to the level of ability possessed by students. Students who have skills in working on synthetic problems must also have higher abilities compared to students who are only able to excel on easy-to-remember questions [11], [12].

Research studies on the Wright-Map application have also been carried out by previous researchers, such as Knoch, using the Wright-Map to test the effectiveness

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of feedback on assessment patterns [13]. Wilson also stated that using the Wright-Map can allow teachers to provide an assessment of the effectiveness of a test item in analyzing variables and the level of difficulty of the questions [14]. Hilaliyah in her research uses the Wright Map to determine the mathematical abilities possessed by students in elementary schools through a grade-up test [15].

In analyzing the achievement test, we will identify students' abilities into 3, namely 1) less than, 2) equal to, or 3) more than the level of difficulty of the item being tested. The purpose of the Wright Map is to show an empirical fact that emerges from the measurement process objectively, not only to describe it constructively. In Wright-Map there are two sides of the panel, left and right. The left panel on the Wright Map shows the ability level area of the respondent, while the right panel shows the item difficulty level area. The Wright-Map application in the Rasch model analysis is generally used for teachers in reconstructing assessment instruments so that they meet the criteria as good quality questions, identify the value and ability level of actual students or based on differences in gender, place of residence or other characteristics, and identify the level of difficulty of the items used as an evaluation test [16].

The purpose of this study was to evaluate the quality of the test instruments tested on the chemical bonding material and to see the consistency of the answers given by students during the exam. In addition, to determine the performance of the Wright-Map in identifying the actual abilities of students and the level of difficulty on the items tested.

2 Research Methods

This study uses a quantitative descriptive method that aims to analyze students' abilities based on the evaluation test of chemistry learning in high school using the Wright Map Rasch modelling. The ability of students and the level of difficulty of item items in Rach's modelling are called person logit and item logit [17], [18].

The subjects of this study were 41 students of class XI senior high school in the city of Surakarta. Data was collected by using a test method using an assessment instrument developed by the author on chemical bonding materials. The preparation of the assessment instrument begins with analyzing the syllabus on the subject of chemical bonds, dissecting the contents of the basic competencies which are then reduced to basic indicators and the last step is making an indicator of 20 items. The indicators of chemical bonds tested include 1) analysis of the process of forming ionic and covalent bonds, 2) determining the type of chemical bonds formed, 3) differences in ionic and covalent bonds from physical and chemical properties and 4) determining the shape of the molecule. Data analysis was carried out using Rasch Model by Winstep 5.1.0 [19].

The data analysis phase is carried out by 1) generating a Wright Map and 2) interpreting the actual abilities of students and the level of difficulty on the items tested. All information obtained from the results of the Wright Map regarding students as persons or respondents in this study is credentialed and managed responsibly.

3 Result and Discussion

3.1 Generating a Wright Map: distribution of questions according to chemical bond indicators

The high potential for bias against chemical test assessment instruments on the subject of chemical bonds in class XI has caught our attention as researchers. The actual ability of students can be known if the instrument used has the quality as a good instrument capable of detecting the abilities of students in detail and depth. To find out that this chemical bond test instrument is correct in identifying the abilities of students, it is necessary to do an analysis using the Wright Map. The results of the Wright Map analysis are in Figure 1.

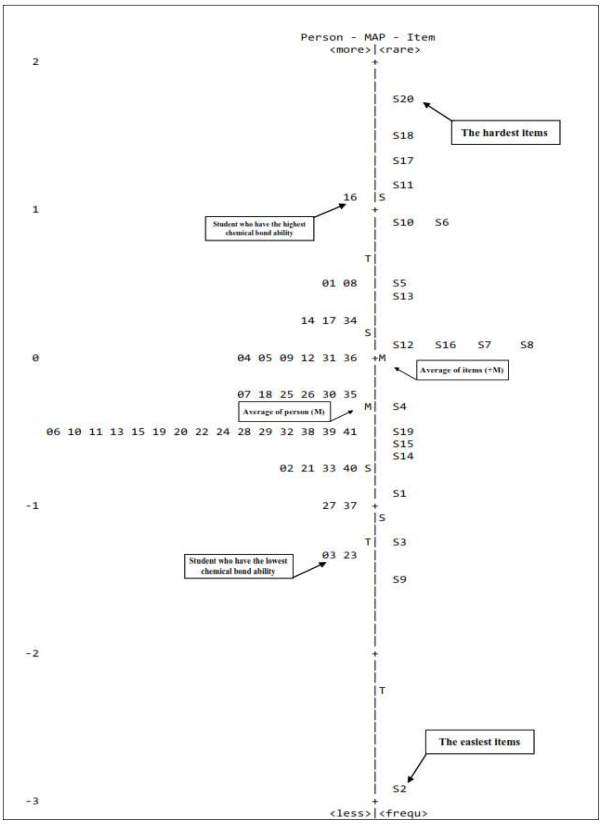


Fig. 1. Result Wright Map.

Figure 1 shows that the chemical bond test instrument questions have an average of 0 which means they are at the equilibrium point. This shows that the distribution of the level of difficulty on the items tested on the chemical bond test is evenly distributed. By looking at the results of the Wright Map in Figure 1, the level of difficulty on the items is divided into four categories, namely easy, currently, difficult and very difficult. In addition to question items, the Wright Map also produces the actual abilities of students. In this study, the average ability of students (person logit) was also 0, so it was divided into three categories namely

high, medium, and low. This is because the criteria for grouping items and students' abilities use the Standard Deviation (SD) value [6]. There are three criteria for checking the suitability of the item questions in Table 1.

Table 1. Criteria the suitability of the item.

Value Logit	Criteria
$0{,}5 < MNSQ < 1{,}5$	Mean Square
$-2{,}0 < ZSTD < +2{,}0$	Z-standard
$0{,}4 < Pt\ Measure\ Corr. < 0{,}85$	Point Measure Correlation

The question difficulty category based on the level of difficulty can be seen in Table 2.

Table 2. Question difficulty category.

Logit value	Category
$> +1{,}09\ SD$	Very difficult
$0{,}0\ logit + 1{,}09\ SD$	Difficult
$0{,}0\ logit - 1{,}09\ SD$	Currently
$< -1{,}09\ SD$	Easy

While the criteria for grouping student abilities (person measure) are in Table 3.

Table 3. The criteria for grouping student abilities.

Logit value	Category
$> +1{,}11$	High
$< +1{,}11$	Medium
$< -0{,}28$	Low

The preparation of the chemical bond test instrument questions is based on 4 indicators. The distribution of chemical bond test questions based on competency indicators is presented in Table 4.

Table 4. Distribution of chemical bond test questions.

No	Competency Indicators	Items
1.	The process of forming ionic and covalent bonds	1, 2, 3, 4
2.	Differences in ionic and covalent bonds from physical and chemical properties	5, 6, 7, 8, 9
3.	Analyzing the type of chemical bonds formed	10, 11, 12, 13, 14, 15
4.	Determination of the shape of the molecule	16, 17, 18, 19, 20

The distribution of questions on the chemical bond test has an even number, namely between 4 to 6 items in each indicator and is adjusted to the cognitive domain (bloom's taxonomy) [11]. The competency indicators used in the evaluation of this chemical bond test are the process of forming ionic and covalent bonds, analyzing the types of chemical bonds formed, differences in ionic and covalent bonds from physical and chemical properties, and determining the shape of the molecule.

3.2 Interpreting Wright Map: student's actual ability vs chemical bond test items

Based on the Wright Map data presented in Figure 1 and the provisions of Table 1, it can be calculated the percentage of the group with the level of difficulty. The percentage of grouping the level of difficulty of the questions on this chemical bond test can be seen in Table 5.

Table 5. The percentage of grouping the level of difficulty of the questions.

Category	Number of Question Items	%
Very difficult	3	15
Difficult	1	5
Currently	13	65
Easy	3	15

Table 5 shows that of 20 items tested, the level of difficulty on the items is divided into four categories, 3 questions are very difficult, 1 question is difficult, there are 13 questions in the current category and 3 easy questions. To know the percentage of the level of difficulty on the items presented in Figure 2.

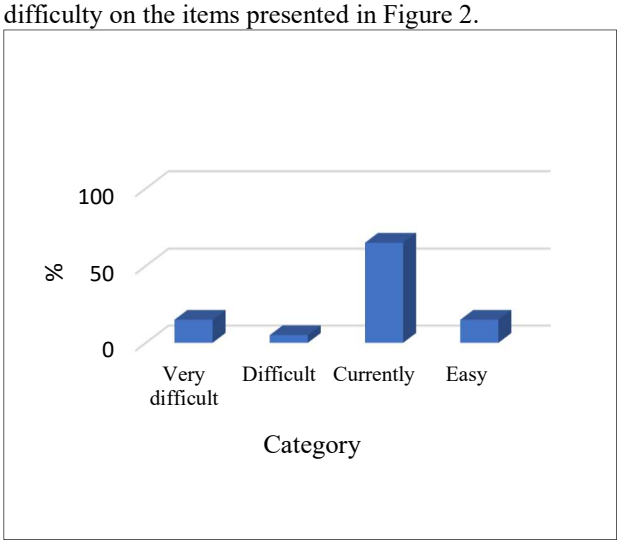
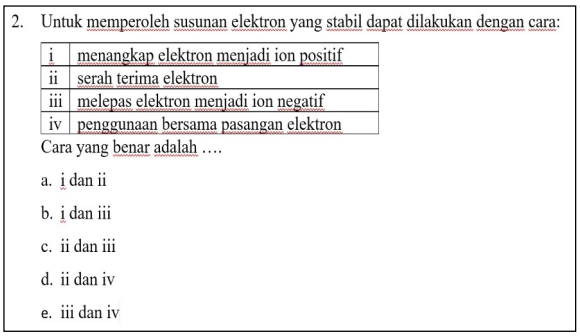


Fig. 2. The level of difficulty on the items.

Based on Figure 2, the percentage of the highest difficulty level for items is in the current category. This is by the average item logit obtained at 0.0 logit and the distribution of questions on the Wright Map is mostly in the logit value of 0.0 – 1.09. However, if you look back at the Wright Map contained in Figure 1, there is 1 question that has a very easy question category. This is due to the influence of the average or logit value generated by students on their abilities. The person measure of the participant's ability is lower than the logit value generated on the item difficulty level. The question in the very easy category is the question no 2. The contents of question no 2 can be seen in Figure 3.


2. Untuk memperoleh susunan elektron yang stabil dapat dilakukan dengan cara:

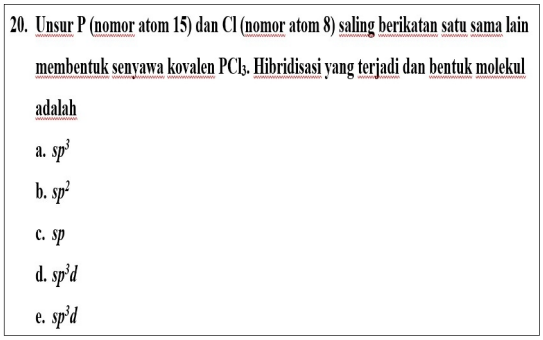
i	menangkap elektron menjadi ion positif
ii	serah terima elektron
iii	melepas elektron menjadi ion negatif
iv	penggunaan bersama pasangan elektron

Cara yang benar adalah ….

a. i dan ii
b. i dan iii
c. ii dan iii
d. ii dan iv
e. iii dan iv

Fig. 3. Items for very easy category questions.

It can be seen that question no. 2 contains a presentation of statements about how atoms become stable and students can choose the correct way through these statements. In this question, the cognitive domain provided is in C2, which is the category of simple conceptual understanding. All students can answer correctly on the question. This shows that the conceptual understanding of students in determining the type of bond through achieving electron stability is very good. This is in line with the research that has been done by several researchers regarding evaluation tests on the subject of chemical bonds. They say that chemical bonding is a material that requires a mature conceptual understanding to achieve maximum student learning outcomes. The higher the level of conceptual understanding possessed by students, they are also able to solve problems containing simple conceptual understanding correctly. In other words, the questions that contain simple conceptual understanding are in the category of very easy questions [20]–[23]. But on the other hand, there is 1 question that is in the very difficult category, namely question number 10. The contents of question number 20 can be seen in Figure 4.


20. Unsur P (nomor atom 15) dan Cl (nomor atom 8) saling berikatan satu sama lain membentuk senyawa kovalen PCl_3. Hibridisasi yang terjadi dan bentuk molekul adalah

a. sp^3
b. sp^2
c. sp
d. sp^3d
e. sp^3d

Fig. 4. Items for very difficult category questions.

In question number 20, the molecules and their atomic numbers are presented, and students are asked to determine the shape of the molecular hybrid orbitals formed. Questions like this are questions in the HOTS category (C4) because they require careful analysis and cannot be solved in one stage. Before determining the shape of the hybrid orbital of a molecule, students must be able to determine the valence electrons possessed by the two elements then students write the valence electrons into the orbital chamber according to the VSEPR rules, then determine the symbol of the chamber, whether the shell is s, p or d. Only then can the hybrid orbital form of a molecule be answered correctly [24].

Of the 41 students who worked on the chemical bond test, the majority had difficulty determining the shape or hybridization of a molecule. As stated by Roger, studying chemical bonds does not only require a conceptual understanding, but an understanding of the principle of chemical bonds also needs to be possessed by students to avoid difficulties and misconceptions [25], [26]. The subject bonding will therefore be treated directly, through consecutive consideration of a set of principles, 1) a chemical bond can be formed if it has eight or two electrons, 2) a chemical bond is formed due to the sharing of electrons by two or more atoms, 3) to bond, atoms must have orbitals with lower energy, and 4) chemical bonds tend to use all available low energy orbitals [27].

In addition to analyzing the difficulty level of the item questions, through the Wright Map we can also find out and analyze the actual abilities of students. Based on the results of the Wright Map shown in Figure 1, it can be seen that 41 people who took the test as respondents had different levels of ability distribution. By the rules in table 2 based on the person measure value, the ability of students should be grouped into three categories, namely high, medium, and low. However, judging from the results of the Wright Map, it turns out that there are four categories of students who take the evaluation test on chemical bonding material. Classification of students' ability levels can be seen in Table 6.

Table 6. Classification of students' ability levels.

Category	Number of people	%
Hard	1	2
Medium	32	78
Low	8	20

Table 6 of 41 students are divided into 3 groups of actual ability, 1 person has a high level of ability, 32 people have moderate ability and 8 people have the low ability. Of the 8 students who were included in the low category, it turned out that 2 students had very low abilities, namely students no. 03 and 23.

These two students must be the main concern of the teacher because they require special handling in terms of learning chemistry in class, especially in chemical bonding material. Conceptual and principal understanding of the subject of chemical bonds is not mastered by them at all. This can be seen in the question items which are included in the easy and very easy categories, they both cannot or have difficulty in solving them. The special treatment given by the teacher to these two students is that they are given assistance and additional lessons outside of class hours and are given simulation questions to stimulate their ability to compete with other students [28], [29]. In addition, there are 6 students in the low ability category. Same with the 2 students earlier, for these 6 students the teacher also needs to pay attention. Because it is possible that these six students are weak in understanding the subject of chemical bonds and there is a tendency that them also experience misconceptions because of these weaknesses. So to avoid misconceptions in students, teachers must choose the right learning model and

evaluation test analysis [30]–[32]. Thus, misconceptions can be avoided and learning objectives can be conveyed properly. To more clearly see the distribution of students' ability levels, it can be seen in the percentage classification of students' ability levels in Figure 5.

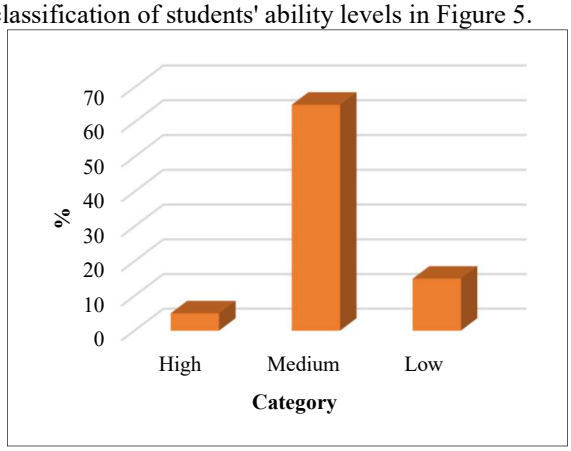


Fig. 5. Classification of students' ability levels.

Out of 41 students, 78% of students can be in the medium ability category. This states that the delivery of chemistry material during learning takes place successfully. It is proven that in working on this chemistry test, the students were able to complete 14 questions as a whole correctly. Because the ability of students with difficulty levels are in the same category, namely. There are only 2% of students can do 17 questions correctly. This is because these students have high abilities. However, there are still 3 questions that 41 students were unable to answer correctly. This is because it has a logit value of +1.5 – +1.8 which is in the very difficult category and the abilities possessed by students have the highest logit value below the logit item value, only +1.2 is classified as capable learners. tall. So students who have a logit person value of +1.2 are still not able to complete these three things correctly. The third question which belongs to the very difficult category is in the fourth indicator, namely realizing the shape of the molecule [33].

Thus, students still have difficulty determining the shape of the molecule and the hybrid molecule. It can be concluded that the class XI participants in one of the SMA cities of Surakarta even though they have high abilities, they are still weak in understanding the principles of complicated bonds in forming a process that does not require coherent steps. So it requires a solution so that this weakness can be overcome, namely by providing a balanced, complete and deep understanding of concepts and principles to students so that the abilities possessed by students are not half full and deep [24]. In addition, using the Wright Map can be a solution to see whether or not there is a bias between students' abilities and the level of difficulty on the items.

4 Conclusion

The results showed that from the beginning of learning conditioning, namely in the pre-cycle without using Power point learning media, 50% were completed while 50% were not completed, it was clear that learning that did not use success media was below classical success, namely in the good category of 80%. Improved learning outcomes occur when conditioning learning using power point media, namely in the first cycle, students who complete 77.78% or 14 students with effectiveness and generate 80% student activity in good category learning. Student learning outcomes in cycle II showed very significant progress because it turned out that 94.45% of students completed or 17 students, while those who did not complete or almost completed were 5.55% or only 1 student. Science learning using Power Point media was very effective. assist students in understanding science learning materials. The results show that the application of using power point learning media can improve learning outcomes and is effective in stimulating interest, motivating and generating student learning activities [9].

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