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Analysis of Student's Chemical Literacy on Buffer Solution Material using the Rasch Model at SMAN 1 Tilatang Kamang

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ABSTRACT

The purpose of this study was analyze the level of chemical literacy of students at SMAN 1 Tilatang Kamang on the buffer solution material using the Rasch model with the Winstep application. This research method is a descriptive study with a quantitative approach with a sample of 75 students of 3th grade students at SMAN Tilatang Kamang. The chemical literacy test was carried out using a chemical literacy-based question instrument amount 11 items. Data on chemical literacy test results were analyzed using the Rasch model. Scalogram analysis based on the ability of student who have high abilities is 35L and student who have lowest ability is subject 02L. Based on the level of difficulty of the items, the most difficult item is number 8 (theme 4) and the easiest item is number 10 (theme 6). Most of the chemical literacy analysis description of students at SMAN 1 Tilatang Kamang are at the Scientific Illiteracy level of 39%.

1. INTRODUCTION

Chemical literacy is the ability to understand the nature of matter perticles, chemical reactions, and the ability to apply chemical concept in everyday life[1]. Chemical literacy requires understanding such as concept and components in chemistry to be able to make decisions based on information that will affect society [2]. The direction of teaching chemistry must consider the problem of its application in everyday life, the application of technological contexts, and social relations that enable one to understand the world and life from science. Chemical literacy is very important to investigate because it is to train people who are chemical literate and it is hoped that students will understand chemistry better[3]. In addition, chemical literacy is also important in the use of chemical concepts in solving problems and being able to apply chemical concepts in everyday life[4], and explaining phenomena, drawing conclusions through scientific evidence, retaining the knowledge gained, and understanding the relevance of the material to the context[5]. Chemical literacy refers to a persons's ability to understand and apply chemistry in everyday life using three aspects such as conscious, knowledge, and applying chemical concepts to life appropriately and effectively[6].

Based on the results of students' tests on the buffer solution material, it was found that 82% of the 105 students had not reached the Minimum Completeness Criteria (KKM). However, the teacher do not yet know the reason of the low test scores, so it is necessary to measure the chemical literacy abilities of students at SMAN 1 Tilatang Kamang. The results of an interview with one of the chemistry teachers at SMAN 1 Tilatang Kamang stated that they had never conducted an evaluation regarding students' chemical literacy skills.

Analysis of students' chemical literacy can be carried out using test instruments that have been developed previously[7]. The instrument is a chemical literacy-based question consisting of 11 items that have been tested for validity and reliability with a validation value of 1.03 in the "valid" category. The measurement of chemical literacy ability is based on the level of scientific literacy that has been developed by Bybee which consists of Scientific Illiteracy, Nominal Scientific Literacy, Functional Scientific Literacy, Conceptual Scientific Literacy, and Multidimensional Scientific Literacy.

Analysis of the participants' chemical literacy skills was not carried out using the Rasch model with an Item Response Theory (IRT) approach because this model ia an appropriate, effective, and systematic data analysis. The question analyzed will represent the level of understanding of students and the size of the question[8]. The Rasch model can explain an event that occurs which in this case is related to an instrument whose data is converted to a logit scale. So, the response will measure a person's character and ability based on the results of the exam[9]. This model is the most appropriate method in basic analysis because it is based on the probability that allows person responses to be predicted accurately and uses only person (test subject) and item parameters[10]. Analysis using race produces accurate analysis results[11]. The analysis was carried out using software in the form of the winstep application which can support the application in the field of learning testing[12].

2. METHOD

This research is descriptive research with a quantitative approach. The data analysis technique uses the Rasch model to reveal the level of chemical literacy of students. The number of samples in this study was 75 students at SMAN 1 Tilatang Kamang. Sampling was carried out using a simple random sampling technique.

The research instrument used was a chemical literacy based item on the buffer solution material. The instrument consists of six discourse texts with 11 essay questions. Theme 1 is about carbonate buffer in blood, theme 2 is about buffer solution experiment in the laboratory, theme 3 is about marathon runners, theme 4 is about buffer in seawater, theme 5 is about soap making, and theme 6 is about buffer solution in shampoo.

3. RESULT AND DISCUSSION

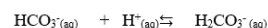### 3.1. Analysis of Chemical Literacy Level on The Item

One of the item used in the chemical literacy analysis of students at SMAN 1 Tilatang Kamang can be seen in Figure 1.

Pernahkah ananda melihat pelari maraton. Pelari maraton dapat mengalami kondisi asidosis, yaitu penurunan pH darah yang disebabkan oleh metabolisme yang tinggi sehingga meningkatkan produksi ion bikarbonat. Meningkatnya produksi ion bikarbonat menyebabkan seseorang merasakan mual, pusing, cemas, gelisah, bingung, dan penglihatan kabur. Olahraga yang berlebihan dapat meningkatkan kadar asam di dalam darah, apalagi yang dilakukan secara terus menerus tanpa istirahat. Di dalam tubuh penyangga karbonat sangat berperan penting dalam mengontrol pH darah agar selalu stabil. Komponen penyangga pada darah yaitu tersusun atas H_2CO_3 dan HCO_3^- yang akan bereaksi jika ada zat yang bersifat asam atau basa masuk ke dalam aliran darah. Reaksi pada darah jika basa yang masuk adalah

$$H_2CO_3^-{}_{(aq)} + OH^-{}_{(aq)} \leftrightharpoons HCO_3^-{}_{(aq)} + H_2O_{(l)}$$
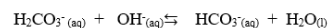
sedangkan ketika asam yang masuk, reaksinya:

$$HCO_3^-{}_{(aq)} + H^+{}_{(aq)} \leftrightharpoons H_2CO_3^-{}_{(aq)}$$

a. Komponen penyangga manakah yang akan bereaksi dalam darah agar pelari marathon tidak mengalami asidosis? Jelaskan!

Figure 1. Example of questions based on chemical literacy

The instrument question used ih the analysis of students chemical literacy at SMAN 1 Tilatang Kamang have an answer rubric with scores adjusted based on the level of chemical literacy that has been developed by Bybee. Based these question, it was

obtained that 48% of students anwers obtained a score of 0; 15% scored 1; 24% got a score of 2; 12% a score of 3; and 1% got a score of 4.

HCO₃⁻ dan H₂CO₃
karena menahan ion H+ dan OH⁻ agar tetap stabil ~~4~~ 0

Figure 2. The pattern of scientific illiteracy answer of 6L student.

Figure 2 describe 6L student which on Scientific Illiteracy, with the answer that the component that will react so the marathon runners don't experience acidosis are HCO3- and H2CO3 because they hold H+ ions and OH- ions to remain stable. This is an incorrect answer because it doesn't match the question where the component that reacts when an acidic substance is added is HCO3-. Based on the level of chemical literacy that has been developed by Bybee, students at this level don't have the vocabulary, conceptual understanding, context, or cognitive capacity so they are unable to respond the question appropriately. The pattern of answer at this level is categorized into two categories, namely the answer of students who don't match the questions and the answer of students who don't understand the concept.

HCO3⁻ yang menyebabkan asidosis karena
adanya ion H+.   1

Figure 3. The pattern of Nominal Scientific Literacy answer of 10P student.

Figure 3 describe the 10P student who get a score of 1 (Nominal Scientific Literacy), with the answer that the component that will react is HCO3- which causes acidosis due to the presence of ion H+ ions. Based on the pattern of students answer, these are answer at the Nominal Scientific Literacy because according to the definition, namely students at this level can know and recognize concepts but haven't been able to define them meaningfully and even show misconceptions about concept that are known and recognized. Patterns of answers at this level it is also categorized into two categories, namely student answers indicating that students haven't been able to define concept meaningfully and student answers showing misconceptions.

Soal nomor 3

Yaitu H/co₃ – yang akan bereaksi di dalam tubuh pelari
marathon sehingga tidak mengalami asidosis /peningkatan
kadar asam di dalam tubuh.   2

Figure 4. The pattern of Functional Scientic Literacy of 30L answer students.

Figure 4 describe 30L student on Functional Scientific Literacy, with the answer that the component that will react so the marathon runners don't experience acidosis is HCO3- which will react in the bodies of marathon runners so they don't experience acidosis or increased acid levels in the body. The students answer pattern is an answer at the Functional Scientific Literacy because it is by what is meant at that level where students can describe concepts correctly but this understanding is still limited.

soal nomor 3
a. HCO₃⁻, karena orang yang mengalami asidosis menyebabkan,
penurunan pH oleh metabolisme tinggi sehingga meningkatkan
produksi ion bikarbonat. Dengan adanya senyawa penyangga
yang mampu mengikat ion H+ sehingga pH darah kita
kembali stabil. 3

Figure 5. The pattern of Conceptual Scientif Literacy answer of 5P student.

Figure 5 describe 30L student who got score 3 (Conceptual Scientific Literacy), with the answer that the HCO3- is the component that will react so the marathon runners don't experience acidosis because people who experience acidosis decrease in pH at high metabolism so that it can increase the production of bicarbonate ions. The presence of buffer can able to bind H+ ions so that the blood pH remains stable. The pattern of students answer includes the Conceptual Scientific Literacy level which has been developed by Bybee which states that at this level students can develop understanding of concepts and relate it to other general knowledge related to science. If seen from the students answers, it can be seen that students can relate the main concept of carbonate buffer components in the blood with the general concept of acidosis (decreased blood pH).

3. HCO₃⁻ + H⁺ ⇌ H₂CO₃ (asam)
Komponen penyangga yang bereaksi dengan ion H+ karena pelari marathon tsb
berolahraga terus menerus tanpa istirahat /berlebihan sehingga dpt meningkatkan
kadar asam di dlm tubuh /darah.   4
H₂CO₃ + OH⁺ ⇌ HCO₃⁻ + H₂O (basa
↓
komponen penyangga yang bereaksi dengan OH⁻ yg juga berperan dlm
mengontrol pH darah agar stabil.

Figure 6. The pattern of Multidimensional Scientific Literacy of 1P answer student.

Figure 6 describe 30L student on Multidimensional Scientic Literacy, with the answer that the component that will react so the marathon runners don't experience acidosis is HCO3- is a buffer component that reacts with H+ ions because these marathon runners exercise continuously without rest or excessively so that it can increase acid levels in the body or blood. This student answer

pattern is an answer for the multidimensional scientific literacy which this is by definition, that is students in this level can develop an understanding of science and relate it to everyday life. Based on the answer above, it can be seen that these student can associate concepts with everyday life and can write down the reaction equation correctly.

The results of the analysis of chemical literacy test items at SMAN 1 Tilatang Kamang can be seen in Figure 7.

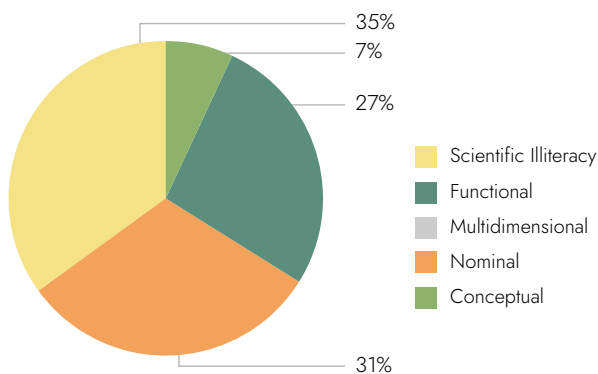**Mapping Chemical Literacy Levels**

Figure 7. Mapping chemical literacy levels

Based on data, it is known that 35% of students get a score of 0 (Scientific Illiteracy), 31% of students get a score of 1 (Nominal Scientific Literacy), 27% of students get a score of 2 (Functional Scientific Literacy), 7% of students get a score of 3 (Conceptual Scientific Literacy), and 0% of students get a score of 4 (Multidimensional Scientific Literacy). Students at SMAN 1 Tilatang Kamang dominated the score 0 and 1 on the chemical literacy test.

3.2. Analysis of Chemical Literacy Level on The Person

3.2.1. Person Measure

To find out the data on the abilities of students, a person-measure analysis is used. Person-measure is the result of converting raw scores that are not linear to the Rasch scale[13]. On the person-measure menu, student data is sorted from the highest to the lowest. The rubric of the chemical literacy based question instrument used has a maximum score of 44 and a minimum score of 0. Students who can achieve the maximum score are indicated to have a good understanding of the buffer solution material and students who can achieve the minimum score, it can be conclude that these students don't understand the buffer solution material. The results of the person-measure analysis of students at SMAN 1 Tilatang Kamang are presented in Table 1.

Table 1. Person Measure analysis.

Subjek	Skor Mentah	Measure
35L	24/44	-0,01
26L	23/44	-0,17
42P	21/44	-0,46
60P	21/44	-0,46
61L	21/44	-0,46
40P	20/44	-0,60
41L	20/44	-0,60
02L	11/44	-3,04

Student of 35L (measure = -0,01) have the highest ability with a score of 24 from maximum score of 44 and student of 02L (measure = -3.04) have the lowest ability with a score of 11 from 44. In addition, there are also students (42P, 60P, and 61P) have the same logit value (measure = -0.46) as well as students of 40P and 41L (measure = -0.60). The same logit value shows the same student abilities. The resulting negative score indicates that the student has low ability on a test[14]. In this chemical literacy test, no one gets the maximum score. The resulting measure value can be used as benchmark to determine the level of chemical literacy of students at SMAN 1 Tilatang Kamang. The higher the measure value obtained, the higher the chemical literacy of students.

3.2.2. Person Fit

Person-fit analysis was carried out to determine the suitability. On the person-fit menu, students who have unfit criteria appear sequentially. Person-fit is an analyisis of checking the actual score pattern against the expected score pattern by the Rasch model[14]. The criteria used to check for discrepancies or person fit are the infit and outfit MNSQ value, namely 0,5<MNSQ<1,5. Data analysis of the MNSQ infit and outfit values in this study can be seen in Table 2.

Table 2. Infit and Outfit MNSQ

Infit and Outfit MNSQ	Persentase
> 1,5	9%
< 0,5	7%

MNSQ infit and outfit value data that are not appropriate show that 16% of the student population in this study has inappropriate response behavior.

3.2.3. Scalogram

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GUTTMAN SCALOGRAM OF RESPONSES:
Person |Item
       |1  1
       |06511739248
       |-----------
    35 +33222322212  35L
    26 +33231312122  26L
    30 +43202222122  30L
    42 +33231312120  42P
    60 +33221312112  60P
    61 +33221212122  61L
    40 +22223222120  40P
    41 +13232112122  41L
     5 +11223311122  05P
    49 +01200010101  49P
     8 +00211010000  08P
     9 +00211010000  09P
    12 +30001010000  12L
    13 +21101000000  13L
    25 +11101010000  25L
    43 +00121010000  43L
     2 +01101010000  02L
       |-----------
       |1  1
       |06511739248
```
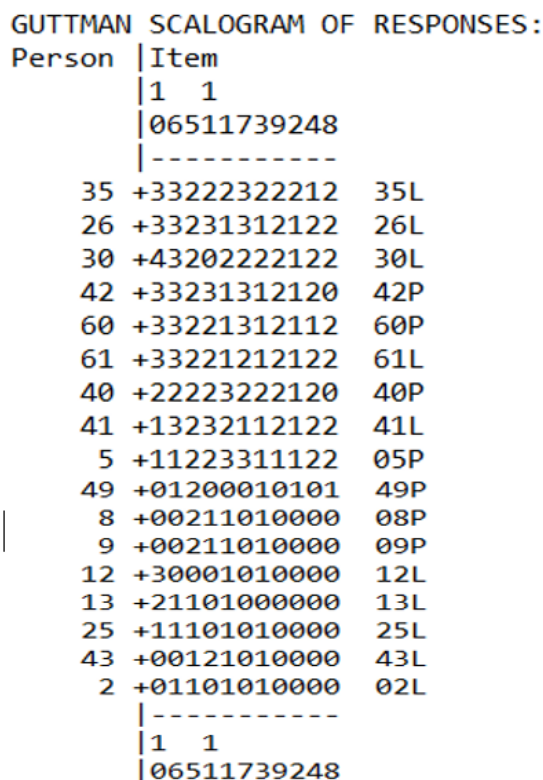
Figure 8. Scalogram

Analyisis of the scalogram will make it easier to find out the reasons why some students give responses (how to do the test) that are not suitable with model. Scalogram analysis raises systematically between the level of ability of students and the level of difficulty of the questions. Students abilities are sorted systematically from the lowest to the highest (from top to bottom). Whereas for the level of difficulty of the items are sorted from the easiest to the most difficulty questions (from left to right). From the data it show that question number 10 is a easiest and question number 8 is a difficulty question.

The ideal answer pattern for analysis using a scalogram is an easy question so the score will be high and otherwise for the difficult question the score will be low[15]. From the data obtained, it shows that 41L student are included in the category of unique student and shows inconsistent answer pattern because question that are classified as easy, the student don't get score optimally, but question that are classified get a high score.

The advantage of the scalogram is being able to detect fraud, namely students who are indicated to be cheating on each other. This can be seen if the same response pattern is found, for example in student of 08P and 09P. In these data, it can be seen that these student have the same chemical literacy.

3.2.4. Wright Map

Analysis using the Wright map cam describe the distribution of students abilities and the distribution of item difficulty levels with the same scale. The Wright map shows that some students have a good understanding by answering questions on the instrument[16]. The Wright map on the left describes the level of ability of students while the right Wright map describes the level of difficulty of the question (item). Data of Wright map can be seen in Figure 9.
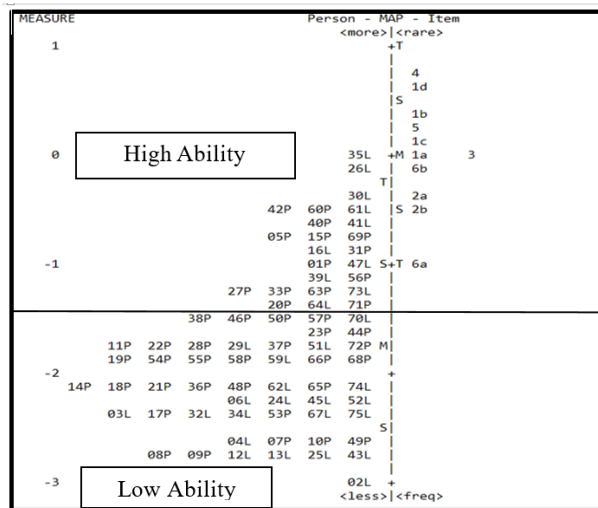

Figure 9. Wright Map

In the Figure 9, it can be seen that question number 4 is the question with the highest level of difficulty and student of 35L have a high ability. In addition, there are also several students (42P, 60P, and 61L) who have the same level of ability and student with the lowest ablity is 02L with a logit value less than -3. These students couldn't work on the question with the lowest level of difficulty, namely question number 6a.

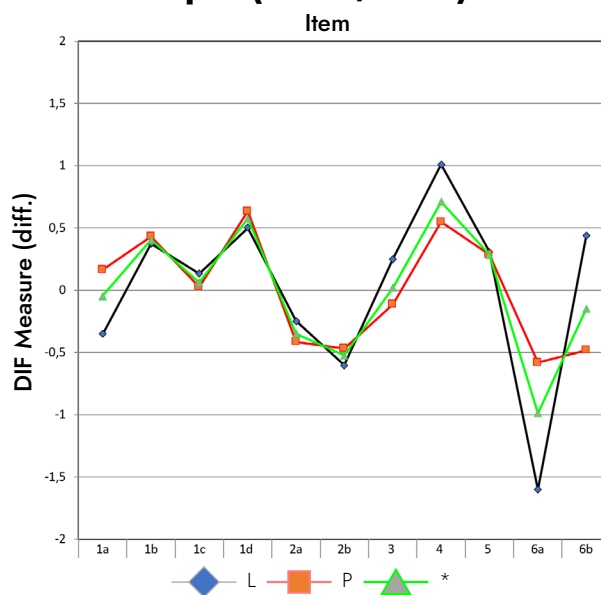### 3.2.5. Differential Item Functioning

Figure 10. DIF kurve

Differential Item Functioning (DIF) in Rasch modeling is used to detect bias. This is used so that the instrument question used do not harm individuals with other characteristics. In the figure above, it can be seen that question number 4 and 1d are a difficult question because it detect the upper limit while question number 6a is an easy because the curve is close to the lower limit. In question number 6a and 6b, there is a bias because it appears that question number 6a is easier for male students to work on than female students while question number 6b is easier for female students to work on compared to male students.

4.CONCLUSION

Based on the results of the chemical test analyisis of students at SMAN 1 Tilatang Kamang on the buffer solution material, it was found that 35% of student were at the scientific-illiteracy level, 31% at the nominal scientific literacy level, 27% at functional-scientific literacy, 7% at conceptual-scientific literacy, and 0% at multidimensional scientific literacy. To improve students chemical literacy ability, it is better to make improvements in the learning process such as in the method, model, and learning media. This effort be desirable to implemented to increase students chemical literacy.

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