CHEMICAL LITERACY INSTRUMENT ON OXIDATION AND REDUCTION REACTIONS MATERIAL THROUGH RASCH MODEL

Eka Yusmaita*1, Fitri Yuliani2, Fauzana Gazali3, Bambang Sumintono4

1,2,3 Chemistry Education, FMIPA, Universitas Negeri Padang
4 Faculty of Education, Universitas Islam Internasional Indonesia

Corresponding author: ekayusmaita@fmipa.unp.ac.id

Abstract. *This study aims to analyze the quality of chemical literacy instrument on oxidation and reduction reactions material using the Rasch model. The instrument construction is based on four domains of chemical literacy which include aspects of content, context, High Order Learning Skills (HOLS), and affective. The instrument assessment rubric is grouped into five levels, namely (1) scientific illiteracy, (2) nominal scientific literacy, (3) functional scientific literacy, (4) conceptual scientific literacy and (5) multi-dimensional scientific literacy. Validation criteria for chemical literacy instrument carried out by five experts include aspects of content, constructs, language, and graphics consisting of thirteen sub questions. The score obtained from validation process is a type of multi-rater data which is analyzed by using the Many-facets of Rasch model. The next stage is empirical study of validated and revised instrument was tested on a limited basis to thirty students and analyzed using the Winstep application. Based on the results of the research, chemical literacy instrument is categorized as valid based on the fit test and unidimensionality test.*

Keywords: *Chemical Literacy, Oxidation and Reduction Reaction, Rasch Model*

INTRODUCTION

Chemical literacy is one of the skills needed in the 21st century among the 16 skills identified by the *World Economic Forum* [1]. Considering the importance of scientific literacy, educating students to have scientific literacy is the main goal in any science education reform [2]. In several countries, scientific literacy is the goal of science education curriculum in the school, one of which is through the *Twenty First Century Science* program in England which aims to develop a science education curriculum. The basis for learning science in the *Twenty First Century Science* program is scientific knowledge (including natural science) and knowledge about science itself [3].

Organization for Economic Cooperation and Development (OECD) has launched one of the international scientific literacy skills assessment programs, that is *Programme for International Student Assesment* (PISA). This program helds every three years [4]. The results of PISA show that the scientific literacy skills of Indonesian students are low. In 2018 Indonesia was ranked 62 in 71 participating countries [5]. Based on several studies on scientific literacy, the low ability of scientific literacy is due to that students are not accustomed to complete tests or problems related to science process skills [6]. The reason why Indonesia score in PISA is low because students are not used to solve discourse-based questions, besides that the assessment process and learning process in the schools also tend not to support students in developing scientific literacy skills [7], also notes that instruments based on scientific literacy are still foreign to students and the application of scientific facts in the science learning process which is still lacking can affect the low ability of students' scientific literacy.

Chemical literacy is a part of scientific literacy [8]. Chemical literacy includes four domains, consisting of knowledge of chemical materials and scientific ideas, chemistry in context, High-Order Learning Skills (HOLS), and affective aspect [9]. Chemical literacy refers to a person's ability to understand and apply chemical knowledge that is owned in everyday life wich consists of understanding aspects of knowledge, awareness, and application of chemistry appropriately and effectively in everyday life [2]. Redox is a chemistry subject whose application is very close to everyday life [10]. Redox can be used to train students' chemical literacy skills [11].

Several studies relevant to this research include research by Fahmina *et al.* (2019) about *Dimension of Chemical Literacy and its Influence in Chemistry Learning* and research by Arabbani *et al.* (2019) about *analysis the quality of instrument for measuring chemical literacy abilities of high school student using rasch model*. The instruments of chemical literacy in some of the studies above are arranged based on the four domains of chemical literacy according to Shwartz *et al.* (2006) which consists of content aspects, context aspects, high order learning skills (HOLS) and affective aspects. However, the chemical literacy instrument in these studies have not covered two or more than two chemical literacy domains in each item.

Students must have chemical literacy skills in chemistry learning. Assessment of chemical literacy skills is needed to support more meaningful learning and it is important to determine the level of achievement of students' understanding of learning [13]. An assessment instrument that can assess chemical literacy skills needs to be developed because to measure achievement in chemistry learning requires an assessment that not only assesses the level of understanding and memorization of students, but is also able to assess the application of students' concepts when facing an issue [14].

A good assessment instrument needs to have several criteria, including validity, reliability and the difficulty level of items [13]. One method that can be used in analyzing test instruments and assessment results is the Rasch model [15]. Rasch model was developed by Georg Rasch and it is part of the item response theory (IRT) one logistic parameter (1PL) [16]. IRT is a measurement that explains the interaction between items and respondents and can produce a more precise and objective measurement [13]. The purpose of this study was to analyze the items of chemical literacy using the Rasch model to obtain an overview of validity, reliability, discriminatory index, and item difficulty level

METHOD

This research is a quantitative descriptive research study. The chemical literacy instrument consisted of fourteen items with essay type. The subjects of this study were senior high school students who studied redox material. The chemical literacy instrument was tested on five validators to determine the validity of the instrument content, as for the content validity of thirteen aspects including material aspects, construction aspects, language aspects and graphic aspects. After obtaining the content validity results, the chemical literacy instrument was tested empirically on thirty high school students, in this study the 2nd year of high school. The data obtained were analyzed using the Rasch model. Content validity analysis was carried out using the Facet application and empirical analysis of students was carried out using the Winstep application.

RESULT AND DISCUSSION

CONTENT VALIDITY

The content validity was obtained through instrument analysis of the experts consisting of five experts, including two lecturers in the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang and three high school chemistry teachers.

Instrument of chemical literacy in redox material consists of 14 items. The content validity test consists of four groups of aspects (1) material/content, (2) construction, (3) language, and (4) graphics with a total of thirteen sub aspects.

EMPIRICAL TEST

Reliability

The results of the reliability analysis of chemical literacy items with the Rasch model can be seen in the *Summary Statistics* table on Winstep application. The information that can be obtained on this menu consists of item reliability, person reliability and Cronbach's alpha value (KR-20) [17]. The reliability value of the chemical literacy instrument is described in Table 1.

Table 1. Summary Statistic

Parameter (N)	Separation	Reliability	SD	KR.20
Person (30)	2.45	0.86	1.06	0.88
Item (14)	2.61	0.87	0.77	

Unidimensionality of Instrument

Unidimensionality of the instrument can be seen in the diagnosis item: Dimensionality Map. Unidimensionality analysis of instruments for chemical literacy can be seen in Table 2.

Table 2. Instrument Unidimensionality

	Eigenvalue	Observed	Expected
Total raw variance in observations	27.2422	100.0%	100.0%
Raw variance explained by measures	13.2422	48.6%	48.5%
Raw variance explained by persons	6.1171	22.5%	22.4%
Raw variance explained by items	7.1251	26.2%	26.1%

Based on Table 2, *the raw variance value explained by measures* the chemical literacy instrument empirically has a value of 48.6% while the Rasch model predicts 48.5%. Meanwhile, *the* unexplained *variance value* of the instrument obtained was less than 15%.

Item Validity

The results of analysis on the chemical literacy items validity are described in Table 3.

Table 3. Item Validity

Number of Item	Outfit		PT Measure Correlation
	MNSQ	ZSTD	
8	1.26	0.83	0.54
13	1.42	1.61	0.56
4	1.34	1.32	0.30
12	1.24	0.97	0.80
1	1.28	1.09	0.43
11	1.12	0.53	0.82
7	0.94	-0.15	0.71
10	0.89	-0.28	0.48
2	0.88	-0.40	0.67
3	0.75	-0.95	0.59
6	0.76	-0.97	0.44
5	0.62	-1.64	0.71
14	0.57	-2.04	0.74
9	0.52	-2.23	0.80

Valid items or questions that have good quality based on the Rasch model can be seen based on the MNSQ, ZSTD and PT Measure Correlation value [17]. The criteria are described in table 4.

Table 4. Item Validity Criteria

Criteria	Coefisien	Decision
OUTFIT MNSQ	0,5 s.d 1,5	Accepted
OUTFIT ZSTD	-2,0 s.d +2,0	Accepted
Pt. Mean Corr	0,4 s.d 0,85	Accepted

Based on Table 4, there are 11 items that fit the MNSQ, ZSTD and PT Measure Correlation criteria, while the other 3 items only meet 2 criteria.

Item Difficulty Level

The difficulty level of items using the Rasch model can be seen in the *Output Table menu; Measure items* on the Winstep application. The difficulty level of items can be grouped by measure values [18].

Table 5. Criteria of Item Difficulty Level

Measure	Item criteria	Item number	Total of items
> 1	Very difficult	8, 10	2
1 - 0	Difficult	1, 2, 3, 5, 7	5
0 – (-1)	Easy	4, 6, 9, 11, 12	5
< -1	Very easy	13, 14	2

The chemical literacy instrument in this study was designed based on four chemical literacy domains and the assessment rubric was arranged based on the level of chemical literacy according to Shwartz. Analysis of chemical literacy items on the oxidation and reduction reaction material for senior high school was carried out in two stages. In the first stage, content validity testing is carried out to find out the correctness of the content that has been designed and to seek recommendations for improvement. Based on the results of the first validation, there were several suggestions from the validator, then improvements were made based on the suggestions given by the validator. The results of the content validity were analyzed using the Rasch model.

Based on the results of content validity analysis in the first stage, there were several items that has not matched the aspects of the instrument assessment. The items that have met all aspects of the assessment are items 1.3, 2.1, 3.1, 4.1 and 4.2, while the other 9 items have not fulfilled all aspects of the assessment of the instrument. The items that at least fulfill the assessment aspect are item number 1.4. In terms of the aspect of assessment, the most difficult aspect to be fulfilled by the items is aspect number 4 (key answer of item is correct), this shows that there are several key answers of items that are not yet correct and need to be corrected along with other aspects that are still not fulfilled. Besides that, the aspects that have been fulfilled by all the items are aspects number 3, 6, 7, 9, 12 and 13.

After obtaining the content validity value, the instrument was tested on students, in this study the chemical literacy instrument was tested on students who had studied oxidation and reduction reaction material. The results of empirical testing of students were analyzed using the Winstep application.

Rasch model can analyze data from the instrument level, the individual level and until the item level. The analysis of instrument validity level is produced through Winstep application, namely testing reliability and unidimensionality. Reliability testing use Rasch model can provide information about the reliability of the items, the reliability of the respondents and Cronbach's alpha (KR-20). Cronbach's alpha is the interaction between respondents and the items as a whole. According to [17] the value of good respondent reliability and item reliability is in the range 0.81-0.90 and Cronbach's alpha value > 80 explains that reliability is at a very good level. Based on the reliability analysis with the Rasch model it shows that the item can be done well by students and students are consistent to answer the items.

Unidimensionality is a measure to evaluate whether or not an instrument can measure what should be measured [19]. Constructively the unidimensionality of the instrument will be of good value if *the raw variance value explained by measures* is above 40% and *the unexplained variance value* is less than 15% [13]. Based on analysis, *the raw variance value explained by measures* of instrument empirically has a value of 48.6% while the Rasch model predicts 48.5%. This shows that the instrument construction is empirically almost the same as the value predicted by the Rasch model. Meanwhile, *the unexplained variance value* of the instrument obtained is less than 15%, the meaning of which the unexplained variance of the instrument is less than 15%. The results of this analysis indicate that the instrument has good construct validity.

Validity is defined as how precisely and accurately a measuring instrument can perform its measuring function [20]. Instrument validity is the extent to which measurement by an instrument can measure the aspects that should be measured. With this, it can be seen whether the instrument used can measure according to the stated objectives [17]. Item validity can be seen based on the value of (1) MNSQ with a value of 0.5 to 1.5, (2) ZSTD with a value of –2.0 to +2.0 and (3) PT measure correlation from 0.4 to 0.85 [18]. According to Palimbong *et al.* (2018) the items of instrument are said to be valid or accep if they cover at least two of the three criteria, if the item only covers one of the three criteria then the item cannot be used. Based on the validity test of 14 chemical literacy items, 11 items have met the three criteria for the MNSQ, ZSTD and PT measure correlation, while the other three items can fulfill two of the three criteria. Items that only meet these 2 criteria include items number 4, 9, and 14. The 4th item (item 1.4) and 14th item (item 4.4) are items that ask about how students respond to an issue or chemical phenomena in everyday life, while 9th item (item 3.4) is a question about elements that act as oxidator and reductor. This means that all chemical literacy items in this oxidation and reduction reactions material are valid or worth to using.

The difficulty level of items using the Rasch model can be grouped based on measure values [18]. The difficulty level of items using the Rasch model can be grouped based on measure values [22]. The level of difficulty of the chemical literacy items was divided into four groups. The group of item difficulty levels regarding chemical literacy in this redox material consists of; (1) two items in very difficult level, (2) five items in difficult level, (3) easy items consisting of five items and (4) two items with very easy categories.

In line with the level of item difficulty, the ability of students in answering chemical literacy questions based on the results of the analysis using the Rasch model can be seen in the variable map. Information about the distribution of items and students' abilities in answering chemical literacy questions on redox material is shown in Figure 1 below.

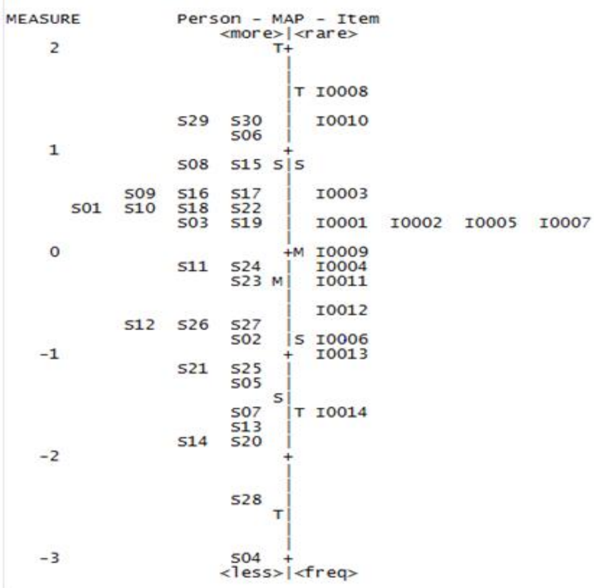

Figure 1. Difficulty Level of Items

Based on Figure 1, the left illustrates the distribution of students' ability and on the right shows the difficulty level of the items. The ability of students from top to bottom is sorted from the highest to students with lower ability. The item that was most difficult for students to answer was 8th item or item 3.2, namely the items regarding oxidator and reductor, based on the answers to the questions given by students, it was found that most students could not determine the change in elemental oxidation numbers from a chemical reaction and only a few students were able to solve the item correctly. The items that are easiest to answer by students is 14th item or item 4.4.

CONCLUSION AND SUGGESTION

Based on the research, can be concluded that the chemical literacy instrument on the material of oxidation and reduction reactions is categorized as valid, the reliability value of the instrument is 0.87 with value of Cronbach' alpha is 0.88, the difficulty level of the items is divided into 4 categories, namely the items that are very difficult, difficult, easy, and very easy. Further research is recommended to use this chemical literacy instrument to obtain a description of the chemical literacy level profile of students in senior high school.

ACKNOWLEDGEMENT

The author would like to thank for Universitas Negeri Padang that has funded this research through PNBP Universitas Negeri Padang in 2020. Thanks to the research team undergraduate students of chemistry education study program

REFERENCES

[1] World Economic Forum, "New Visionfor Education. 2015. Unlocking the Potential of Technology," in *AIP Conference Proceedings*.

[2] R. Thummathong and K. Thathong. 2016. "Construction of a chemical literacy test for engineering students," *J. Turkish Sci. Educ.*, vol. 13, no. 3, pp. 185–198.

[3] R. Millar. 2008. "Taking scientific literacy seriously as a curriculum aim," *Asia-Pacific Forum Sci. Learn. Teach.*, vol. 9, no. 2, pp. 1–18

[4] O. W. Astuti, Zulyusri, and D. H. Putri. 2017. "Pengembangan Instrumen Asesmen Berbasis Literasi Sains pada Mata Pelajaran

IPA Kelas VIII Semester II (Development of the Scientific Literacy Assessment Based on Science Subjects Class VIII Semester II),” *Biosains*, vol. 1, no. 2, pp. 227–234.

[5] Y. F. Narut and K. Supardi. 2013. “Literasi Sains Peserta Didik dalam Pembelajaran IPA di Indonesia,” *Inov. Pendidik. Dasar*, vol. 3, no. 1, pp. 61–69.

[6] M. Imansari, W. Sumarni, and Sudarmin. 2018. “Analisis Literasi Kimia Peserta Didik Melalui Pembelajaran Inkuiri Terbimbing Bermuatan Etnosains,” *J. Inov. Pendidik. Kim.*, vol. 12, no. 2, pp. 2201–2211.

[7] S. Afifah and E. Yusmaita. 2019. “Perancangan Assesmen Literasi Kimia Pada Materi Termokimia Kelas XI SMA / MA,” *EduKimia*, vol. 1, no. 4, pp. 79–83.

[8] S. Rahayu. 2017. “Mengoptimalkan Aspek Literasi dalam Pembelajaran Kimia Abad 21,” in *Prosiding Seminar Nasional Kimia UNY 2017. Sinergi Penelitian dan Pembelajaran untuk Mendukung Pengembangan Literasi Kimia pada Era Global*.

[9] Y. Shwartz, R. Ben-Zvi, and A. Hofstein. 2006. “The use of scientific literacy taxonomy for assessing the development of chemical literacy among high-school students,” *Chem. Educ. Res. Pract.*, vol. 7, no. 4, pp. 203–225.

[10] D. A. Sari and S. Hayani. 2015. “Implementasi Strategi Pembelajaran Berbasis Masalah Berbantuan Flash Materi Redoks,” *Chem. Educ.*, vol. 4, no. 1.

[11] A. I. F. Riyadhin and Mitarlis. 2018. “Pengembangan Lembar Kegiatan Siswa (LKS) untuk Melatihkan Kemampuan Literasi Sains Siswa pada Materi Redoks,” *UNESA J. Chem. Educ.*, vol. 1, no. 1, pp. 8–13.

[12] S. S. Fahmina, N. Y. Indriyanti, W. A. E. Setyowati, M. Masykuri, and S. Yamtinah. 2019. “Dimension of Chemical Literacy and its Influence in Chemistry Learning,” *J. Phys. Conf. Ser.*, vol. 1233, no. 1.

[13] F. K. Arabbani, S. Mulyani, L. Mahardiani, and S. R. D. Ariani. 2019. “Analysis the quality of instrument for measuring chemical literacy abilities of high school student using Rasch model,” *AIP Conf. Proc.*, vol. 2194, no. December.

[14] W. Sumarni, H. W. Prasida, and S. S. Sumarti. 2017. “Pengembangan Instrumen Penilaian Kemampuan Kognitif dan Afektif Berbasis Literasi Sains pada Materi Larutan Penyangga,” pp. 457–467.

[15] A. Rusilowati. 2018. “Asesmen Literasi Sains: Analisis Karakteristik Instrumen dan Kemampuan Siswa Menggunakan Teori Tes Modern Rasch Model,” *Pros. Semin. Nas. Fis. Univ. Riau ke-3*, no. September, pp. 2–15.

[16] B. Sumintono. 2014. “Model Rasch untuk Penelitian Sosial Kuantitatif,” *ITS Surabaya*, no. November 201, pp. 1–9.

[17] B. Sumintono and W. Widhiarso. 2014. *Aplikasi Model Rasch untuk Penelitian Ilmu-Ilmu Sosial. Edisi Revisi*. Jakarta: Rajawali Pers.

[18] S. A. Perdana. 2018. “Analisis Kualitas Instrumen Pengukuran Pemahaman Konsep Persamaan Kuadrat Melalui Teori Tes Klasik Dan Rasch Model,” *J. Kiprah*, vol. 6, no. 1, pp. 41–48.

[19] S. Wibisono. 2014. “Aplikasi Model Rasch untuk Validasi Fundamentalisme Agama bagi Responden Muslim,” *Pengukuran Psikol. dan Pendidik. Indones.*, vol. 3, no. 3, pp. 729–750.

[20] Supardi. 2016. *Penilaian Autentik Pembelajaran Afektif, Kognitif dan*

Psikomotor. Jakarta: Rajawali Press.

[21] J. Palimbong, Mujasam, and A. Y. T. Allo. 2018. "Item Analysis Using Rasch Model in Semester Final Exam Evaluation Study Subject in Physics Class X TKJ SMK Negeri 2 Manokwari," *Kasuari Phys. Educ. J.*, vol. 1, no. 1, pp. 43–51.

[22] Susdelina, Perdana, S. A., & Febrian. 2018. Analisis Kualitas Instrumen Pengukuran Pemahaman Konsep Persamaan Kuadrat Melalui Teori Tes Klasik Dan Rasch Model. Jurnal Kiprah, 6(1), 41–48. https://doi.org/10.31629/kiprah.v6i1.574.