

Design of Chemical Literacy Assessment by Using Model of Educational Reconstruction (MER) on Solubility Topic

EYusmaita* and Edi Nasra

Departement of Chemistry education, Universitas Negeri Padang

*ekayusmaita@fmipa.unp.ac.id

Abstract. This research aims to produce instrument for measuring chemical literacy assessment in basic chemistry courses with solubility topic. The construction of this measuring instrument is adapted to the PISA (Programme for International Student Assessment) problem's characteristics and the Syllaby of Basic Chemistry in KKNI-Indonesian National Qualification Framework. The PISA is a cross-country study conducted periodically to monitor the outcomes of learners' achievement in each participating country. So far, studies conducted by PISA include reading literacy, mathematic literacy and scientific literacy. Referred to the scientific competence of the PISA study on science literacy, an assessment designed to measure the chemical literacy of the chemistry department's students in UNP. The research model used is MER (Model of Educational Reconstruction). The validity and reliability values of discourse questions is measured using the software ANATES. Based on the acquisition of these values is obtained a valid and reliable chemical literacy questions. There are seven question items limited response on the topic of solubility with valid category, the acquisition value of test reliability is 0,86, and has a difficulty index and distinguishing good

1. Introduction

Assessment is an important component of learning process and national standards have been set demands to educators to have the ability for doing an assessment to students. Although an educator has the knowledge and teaching skills, knowledge about evaluate is requisite in indicated for effective learning. The educators' ability in assessing students learning outcomes will have a huge impact in how successful achievement of students.

In education, there are several International assessment are often performed among others TIMSS, PIRLS and PISA. PISA looked at science education have function to prepare citizens in the future, that citizens are able to participate in society increasingly affected by the progress of science and technology. Therefore, science education should develop students' ability to understand the essence of scientific, scientific procedures, as well as the strengths and limitations of scientific. Related with the ability of scientific literacy indonesian students, assessment study performed by the PISA (*Program for International Student Assessment*) revealed that science learning is less successful to improve students scientific literacy. In 2000 Indonesia was ranked 38 out of 41 participating countries in PISA with mean value tests 393; in 2003 Indonesia was ranked 38 out of 40 participating countries with a mean value tests 395; In 2006 Indonesia was ranked 50 out of 57 participating countries with mean value tests 393; in 2009, Indonesia was ranked 60 out of 65 participating countries with score 383 (OECD, 2009) and in 2012 Indonesia was ranked 64 out of 65 participating countries. The results of PISA 2015 literacy released 6th December 2016, Indonesia was ranked 62 out of 70 participating countries, tests



and PISA survey subsequent is in 2018 with test results and survey will be released in the end 2019. (Kemendikbud.go.id. 2016).

This research is important to do, the monitoring results of PISA to Indonesian students is very disappointing, therefore need a fundamental and relevant ideas to the design of chemical literacy assessment that refers to PISA is an innovation in the field of education are very possible to be realized. It is based in scientific literacy as part of PISA, making chemicals as part of the PISA too. With created chemical literacy assessment that valid and reliable, expected be able to give an overview of how the profile undergraduate difficulty in answering basic questions test chemical literacy in the basic chemistry course. In nowadays, no research yet that study about design of chemical literacy assessment in basic chemistry courses. However, there are relevant research supporting this research, among others conducted by Firman, H (2007) about analysis of students difficulties in answering basic scientific literacy test based on the results of the National PISA 2006; research conducted by Cigdemoglu Ceyhan, et al (2012) about the efforts to increase levels of chemical literacy in thermochemical and thermodynamic concepts using context-based approach; research conducted by Yusmaita,E (2013) about Construction of teaching materials based on *green chemistry* to build students' scientific literacy; and research conducted by Suat Celik (2014) about how levels of the chemical literacy in a prospective educator MIPA.

The importance of literacy assessment emphasized by Heritage (2007: 141), as follows: "*The educators learn how to teach without learning a lot about how to assess*". Furthermore, Stiggins (2004: 16) asserts that a quarter to one-third the time teachers should be used for the assessment related the learning process. Therefore, educators must know and understand the principles of valuation. Assessment is an important process because the results can be used to plan instruction, guide student learning, determining the level/order, making a difference, decisive for further education, development of educational theory, formulating policies, allocate resources and evaluate the curriculum (NRC, 1996: 76). Therefore, the assessment needs to be planned, conducted, and analyzed properly so as to function properly. Here, the plan targets and indicators of achievement outcomes expected in this study.

2. Research Methods

2.1. Study Design

Design of this study using the Model Reconstruction of education, which is a cycle of form *the cyclic* which can be alternating (*recursive*). The third component of the MER related to each other and forming a systematic groove (Duit, *et al.*,2012: 26). For more details see the Figure 1

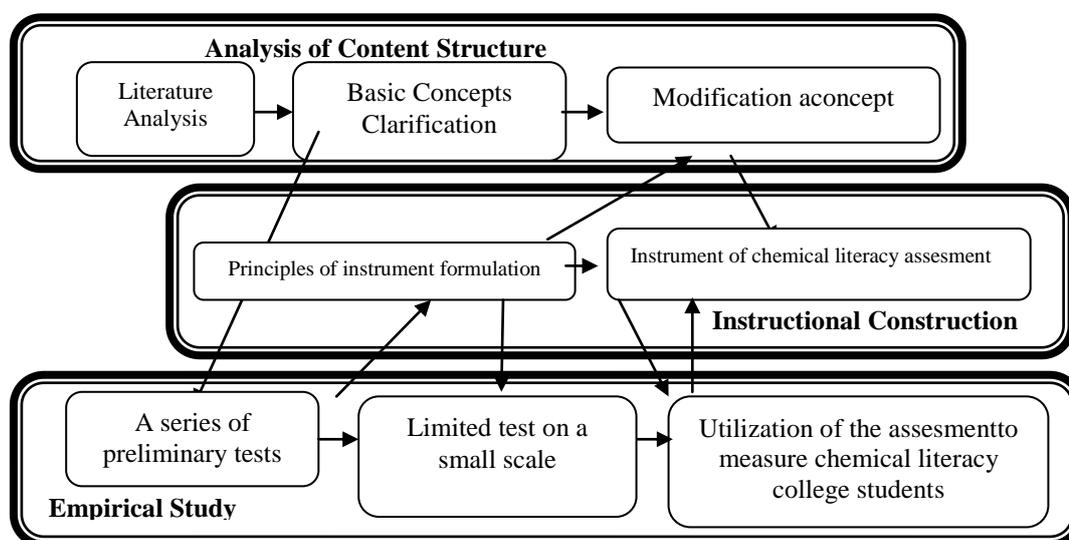


Figure 1. Modification Model of Educational Reconstruction

Figure 1 presents a repetitive process that occurs between the three components of education reconstruction model. Overall contribution to the MER can be seen in the preparing the science component framework that relevant to science education research and development and thereby forming a *trilateral* relationship.

In practice, all the stages of the first component of this model does not absolutely have to be resolved first. Research process can be alternating (*recursive*) so that in perfecting the first component is affected also by the second and third components. Components of the first, second, and third performed with interleaving depend with the purpose and importance of the research will be achieved (Yusmaita, 2014: 45).

The method used in this study is a mixed methods. Another term to mention mixed methods very diverse, such as multi-method, convergence method, integrated method, and combination method (Creswell & Clark, 2007; Creswell, 2012: 22). Sources of data in this study was obtained by data triangulation, such as seeking the convergence between of qualitative methods and quantitative methods (Creswell, 2012: 22).

2.2. Research Phase

2.2.1. Analysis of Content Structure

Literature analysis

This study consists are a analysis of Basic Chemistry Course Syllabus KKNi and PISA study. Learning outcome that expected in this course are: Students can describe the condition of particle in solution and colloid and specific trait that arise as well as calculation and its usefulness; describes the determinant of the reaction rate and as well as calculation and its usefulness; redox reactions in an electrochemical cell as well as the calculation and its usefulness; describes the trait similarity elements of a class and the important compounds these elements; to explain the circumstances of nucleons in the nucleus and the changes that happened as well as the usefulness of such changes; describes organic compounds and their usefulness and reactions; and explains the important compounds in the organism and its role. In this study, basic chemical material is restricted to the concept of "Solubility".

Clarified content structures through chemistry textbook

One of component Model of Educational Reconstruction (MER) is content structure clarification. Content structure clarification on the solubility material refers to books Brady, James E and Fred Senese with title matter and its changes Chemistry, 6th edition and basic chemical book University composition sixth and the second books, Chemistry for University by Keenan, Charles W; Kleinfelter Donald C. Kleinfelter and Wood Jese H.

Modification a concept

The process of concept modification is a process of revising the instrument after testing the test on a small scale.

2.2.2. *Empirical Study.* Empirical investigation conducted by conducting laboratory tests and limited test on a small scale.

2.2.3. *Assessment Construction.* Construction questions chemicals literacy designed by three types of representation. It consist of aspek macroscopic, microscopic, dan symbolic levels.

2.3. Research sites

The research was conducted in the first year students who take Basic chemistry courses in the Department of chemistry, Padang State University. The participants consisted of 62 undergraduate chemistry students. Implementation of this research was conducted in semester January-June 2017.

2.4. Instruments and Data Analysis

Analysis of the test is one of the activities in order to construct a test to get an image about the quality of the test, both the overall quality of the test and the quality of each item. Analyzes were performed

after the tests are prepared and tested to all subjects and the results fed back to the relevant test quality improvement (Mahmud, 2014).

One way to test analysis and question item is anates which is a computer application program that aims to analyze the question item. The program is especially useful for teachers in general observers education evaluation. The program was developed by Drs. Karno To, M.Pd. a professor of psychology at UPI and Mr. Yudi Wibisono, ST a computer consultant.

Facilities at ANATES V4

- a. Scoring data, include:
 - Input score data, test outcomes
 - Weighting score data according to the required
- b. Processing of data, including
 - The Reliability
 - Group superior and asor
 - Power differentiator
 - Level of difficulty Problem
 - Correlation item score with total score
 - Detractors quality (Siswoyo.2013)

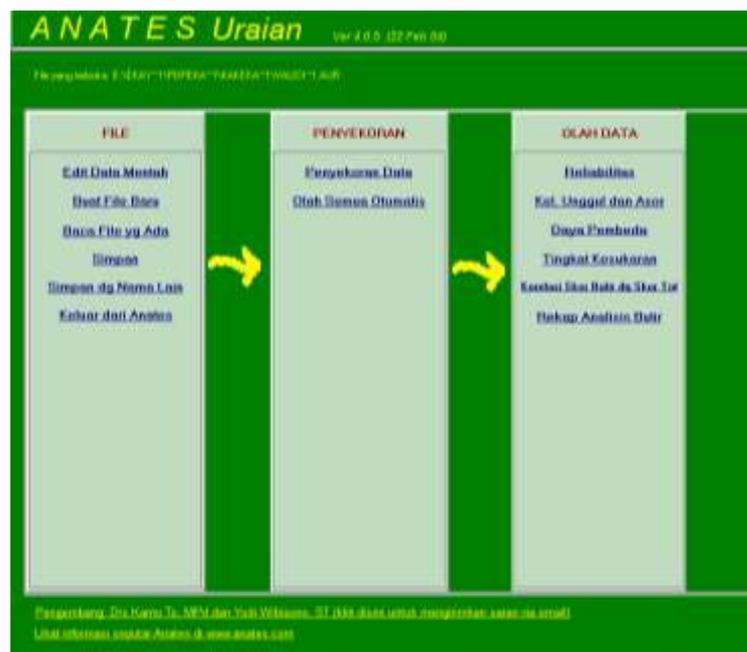


Figure 2. Interface software ANATES

3. Results

The form of the test that used in the assessment of chemical literacy undergraduate students is assessment test limited response that includes two types, namely short fill type and multiple choice. In this test students are expected to be able to analyze the level of saturation of each solution by completing description image on the macroscopic aspects, microscopic and the symbolic. Discourse solubility text described into seven question items, where the level of thinking that used in designing this question includes a low level to high, with balanced proportions.

This designing assessment using the Model of Educational Reconstruction (MER), which consists of three components. Description the third cycle of these components can be seen in Figure 2.1. This cycle is back and forth, so in the implementation when the component one has not been completed in

the middle of the process can be continued with two or three components. Otherwise, when the three components is being processed can return again to one or two components. The function of third components that recursive are as reinforcement between the components with one another.

In this reseach, the component is first performed analysis of content structure includes analysis of the syllabus KKNI university and analysis PISA competency that expected. Based on this analysis, obtained PISA competency about scientific phenomena which apply science knowledge on the situation-condition which it is given, describing or interpreting scientific phenomena and predicting changes, identifying the explanation and appropriate descriptions. Description from this analysis produce question indicators, wich then used as a benchmark in designing narrative discourse text. The truth of this narrative discourse text is clarified through the text book of the university and test question validation is done before the measuring instrument is tested with rational analysis through professional judgment, namely make discussion with lectures according to their scholarly expert. Measurement validity of this method is known as contentvalidity.

The next stage is tested validity of question content in the laboratory through experiments. Acquisition of data and images for this empirical study was made as complementary material of text discourse on macroscopic aspects. Then continued in the stage instrument construction by adding microscopic aspects and symbolic in the question. The trial is limited to text discourse was conducted to 31 students by using ANATES software. This test aims to obtain reability, differentiation, and level difficulty of the question. In this section, Analysis result of student’s responses are presented.

3.1. Reabilitas test

As indicated in Table 1, the acquisition value of test reliability is 0,86. It can be concluded that test device classified have high reliability. It means that the test showed consistent results.

Table 1. The distribution of reliability sample

RELIABILITAS TES						

Rata2= 12,97						
Simpang Baku= 5,26						
Korelasixy= 0,73						
Reliabilitas Tes= 0,86						
Nama berkas: E:\EKA Y\VALIDITAS SOAL ANGGATAN 2014.ALR						
No. Urut	No. Subyek	Kode/Nama Subyek	Skor Ganjil	Skor Genap	Skor Total	
1	1	Annisa Rahim	9	7	16	
2	2	Aseiyunda	4	2	6	
3	3	Dilla wahyuni	6	4	10	
4	4	Dira Yulia Dasti	5	7	12	
5	5	Febriani	11	5	16	
6	6	Fitria Yolanda	6	6	12	
7	7	Intan Selvi M...	11	5	16	
8	8	Neliza Novita...	8	5	13	
9	9	Nitra Susanti	5	0	5	
10	10	Nutia Apriani	12	9	21	
11	11	Nivelda Yani H	8	3	11	
12	12	Novi A	11	6	17	
13	13	Putri Handayani	11	7	18	
14	14	Reza Amelia	6	5	11	
15	15	Siti Nur will Y	12	9	21	
16	16	Wulandari Dwi...	7	5	12	
17	17	Andina Febria...	9	9	18	
18	18	Annisatul Qaidah	3	4	7	
19	19	Arni Saragih	4	2	6	
20	20	Chairun Nisa	9	9	18	
21	21	Diana Safitri	5	4	9	
22	22	Fitria Harni ...	5	3	8	
23	23	Hanifiyati samha	10	8	18	
24	24	Jusmalara Ais...	3	1	4	
25	25	Mugi Santoso	10	9	19	
26	26	Mugi widodo	10	9	19	
27	27	NaDia Afi Sha...	5	4	9	
28	28	Resa Afrina	8	5	13	
29	29	Risca Cahya A...	10	7	17	
30	30	Raissa Elvia ...	2	1	3	
31	31	Riris Juniati...	8	9	17	

3.2. Distinguishing Power

Result in Table 2 show that most of item test have distinguishing between The top group (students who have high ability) with a lower group (students who have low ability) in good category.

Table 2. The distribution of distinguishing question

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DAYA PEMBEDA
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Jumlah subyek= 31
Klp atas/bawah(n)= 8
Butir Soal= 7
Un: Unggul; AS: Asor; SB: Simpang Baku
Nama berkas: E:\EKA Y\VALIDITAS SOAL ANGKATAN 2014.AUR

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No	No Btr Asli	Rata2Un	Rata2AS	Beda	SB Un	SB As	SB Gab	t	DP(%)
1	1	2,88	2,13	0,75	0,35	0,99	0,37	2,02	25,00
2	2	2,88	1,25	1,63	0,35	1,04	0,39	4,20	54,17
3	3	2,13	1,13	1,00	0,35	0,83	0,32	3,12	33,33
4	4	3,13	0,63	2,50	0,35	0,52	0,22	1...	62,50
5	5	2,75	0,13	2,63	0,89	0,35	0,34	7,78	65,63
6	6	2,63	0,25	2,38	0,74	0,46	0,31	7,67	59,38
7	7	2,63	0,50	2,13	0,52	0,53	0,26	8,08	53,13

3.3. Difficulty Index

Based on index percentage difficulty levels of question , question number 1 in the category of easy because as many as 83.33% of students were able to answer the question correctly. This condition is commonly done in the design question that starts with an easy question then increased to medium and hard. The lowest percentage difficulty levels of question is owned by item numbere 5 and 6, wich is 35,94% and this is still included in the interpretation of average categories.

Table 3. The Distribution of difficulty index question

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TINGKAT KESUKARAN
=====
Jumlah Subyek= 31
Butir Soal= 7
Nama berkas: E:\EKA Y\VALIDITAS SOAL ANGKATAN 2014.AUR

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No Butir Baru	No Butir Asli	Tkt. Kesukaran(%)	Tafsiran
1	1	83,33	Mudah
2	2	68,75	Sedang
3	3	54,17	Sedang
4	4	46,88	Sedang
5	5	35,94	Sedang
6	6	35,94	Sedang
7	7	39,06	Sedang

Based on the analysis question of chemical literacy by using ANATES software, question in the bad category will be revised and modified. For the next used on a wider scale, namely as many as 62 first-year students who had been taking basic chemistry course.

4. Conclusion

Design of chemical literacy instrument on solubility topic using model of educational reconstruction. In general, this model consist of three components, namely content structure analysis, empirical study to the field and instrument constructs. The process of implementation of these three components run recursive. There are seven question items limited response on the topic of solubility with valid category, the acquisition value of test reliability is 0,86, and has a difficulty index and distinguishing good. The instrument has been designed then will be used to determine and mapped how the profil achievement chemical literacy that obtained by the first-year students department of chemistry.

References

- [1] Allahyari, T., Rangi, N. H., Khosravi, Y., dan Zayeri, F. 2011. Development and Evaluating of A New Questionnaire for Rating of Cognitive Failures at Work. *International Journal of*

Occupational Hygiene. (3), 6-11

- [2] Arifin, Zaenal. 2009. *Evaluasi Pembelajaran*. Bandung: PT Remaja Rosdakarya.
- [3] Arikunto, S. 2002. *Prosedur Penelitian suatu Pendekatan Praktek*. Edisi V. Jakarta:
- [4] Rineka Cipta.
- [5] Celik, S. 2014. Chemical Literacy Levels of Science and Mathematics Teacher Candidates. *Australian Journal of Teacher Education*. 39(1): 1-13.
- [6] Cigdemoglu, C., Geban, O. 2012. Improving students's Chemical Literacy Level on Thermochemical and Thermodynamics Concepts through Context-Based Approach. *Chemistry Education Research and Practice*. 1-15.
- [7] Creswell, J.W. 2012. *Research Design, Pendekatan Kualitatif, Kuantitatif, dan Mixed*. A.b. Fawaid, A. Yogyakarta: Pustaka Pelajar.
- [8] Duit, R. 2007. Science Educational Research Internationally: Conception, Research Method, Domain Research. *Eurasia Jurnal of Mathematics*. 3, (1), 3-15.
- [9] Duit, Reinders,dkk. 2012. The Model Of Educational Reconstruction – A Framework For Improving Teaching And Learning Science. *Science Education Research and Practice in Europe*. Netherlands: Sense Publishers.
- [10] Firman, H. 2007. *Laporan Analisis Literasi Sains Berdasarkan Hasil PISA Nasional Tahun 2006*. Jakarta: Pusat Penilaian Pendidikan Balitbang Depdiknas.
- [11] Flynn, A. B., Amellal, D .G. 2015. Chemical Information Literacy: pKa Values-Where Do Students Go Wrong?. *Journal of Chemical Education*. 1-18.
- [12] Gabel,D.L. 1993. *Handbook of Research on Science Teaching and Learning*. New York: Mac. Millan Company.
- [13] Laherto, A. 2012. *Nanoscience Education for Scientific Literacy. Opportunities and Challenges in Secondary School and in out-of-school Settings*. Helsinki: *Academic Dissertation*.
- [14] Lawshe. 1975. A Quantitative Approach to Content Validity. *Journal Personnel Psychology*. 28, 563-575.
- [15] Marzono, R.J. 1994. *Assesing student Outcome: Performance Assesment Using the Dimentions of Learning Model*. Alexandria: Association for supervision and Curriculum Development.
- [16] NRC.1996. *National Science Education Standards*. Washington: National Academic Press.
- [17] OECD. 2009. *PISA 2009 Assessment Framework Key competencies in reading, mathematics and science*. [online]. Tersedia:[http:// www.oecd.org/dataoecd/11/40/44455820.pdf](http://www.oecd.org/dataoecd/11/40/44455820.pdf)
- [18] Resnick, D.P. 1985. Standars, Curriculum, and Performance: A Historical and Comperative Perspektive. *Educational Researcher*.9. 5-19.
- [19] Shwartz, Y., Bhen-Zvi, R., and Hofstein, A. (2006). “The Use of Scientific Literacy Taxonomy for Assessing the Development of Chemical Literacy Among High-School Students”. *Chemical Education Research and Practice*. 7,(4), 203-225.
- [20] Siswoyo, D. (2013). *Anates V4 Software Analisis Data*
- [21] Stiggins, R.J. 1994. *Student-centered Classroom Assessment*. New York: Mac.millan College Publishing Company.
- [22] Tola, B. 2008. *Literasi Sains Siswa Indonesia: Asesmen dan implikasinya*. Makalah pada Seminar Nasional Kimia dan Pendidikan Kimia, Bandung: FPMIPA UPI.
- [23] Toharuddin, Uus, dkk. 2011. *Membangun Literasi Sains Peserta didik*. Bandung: Humaniora.
- [24] Yusmaita, Eka. 2013. *Konstruksi bahan ajar berbasis green chemistry untuk membangun literasi sains siswa*. *Tesis*. Sekolah Pascasarjana UPI, Bandung.
- [25] Wilson, R., Pan, W., dan Schumsky, D.A. 2012. Recalculation of the Critical Values for Lawshe's Content Validity Ratio. *Association for Assesment in Counseling and Education*. [online].