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Developing an instrument of scientific literacy assessment to measure natural science teacher candidates in force subject

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Abstract. The aim of this study to develop an instrument of scientific literacy assessment that tested its validity, reliability, characteristics, and described the skills of natural science teacher candidates, consist of three aspects based on PISA 2015 as follow: cognitive, competence, and affective aspect. The subjects are 2nd semester natural science teacher candidates at Universitas Negeri Semarang. Test validity has been done by the content, construct, and concurrent validity. Test reliability has been done by calculating a reliability coefficient “r”. Characteristics tested by determining the level of difficulty and distinguishing features. Profile of scientific literacy skills is determined by measuring natural science teacher candidates’ mastery of scientific literacy. The result of a reliability test is the value of “r” is 0.71 in high category. Validity test results showed that the instrument fulfils the content, construct and the concurrent validity with very valid category and strong validity. The characteristics of developing an instrument assessment showed that the instrument has a level of difficulty that the proportion is 26.7%. The result of distinguish analysis obtained 56.7% of the items with the good quality. Profile of scientific literacy skills showed that the cognitive and competency aspect of natural science teacher candidates is very low and the affective aspect is good.

1. Introduction

In the 21st century, the global citizenship is entering a new era where changes in various fields, especially in the fields of science and technology education in developing countries where improve rapidly. Science education can build students thinking for understanding natural science phenomena or occurences that accured using scientific methods as scientists did [1]. Scientific literacy is very important for students as a provition to face the challenges of development 21st century. This is conformity with [2] that scientific literacy directly correlates with a new generation building who has strong scientific thinking and attitudes, then they can communicate effectively about knowledege and the result of research to the general society.

Scientific literacy emphasized students to analyze, predict, and apply scientific concept in everyday [3]. The United States National Center for Education Statistics [4] defined scientific literacy as knowledge, concept comprehension, and scientific processes that students needed to make personal decisions, contribute to cultural and social activities, and economic productivity. One of the efforts to measure scientific literacy skill of prospective science teacher students is preparation of evaluation with scientific literacy test. This test to find out the scientific literacy skill profile of natural science teacher candidates.

Aspects of scientific literacy skills include: the role of science, scientific thinking and doing, science and society, mathematics in science, and science motivation and beliefs [5]. According to [6]



to measure scientific literacy skills students can use several questions from PISA. A person's understanding of science can be seen from how they argue about the problems issued by PISA. There are three aspects of scientific literacy measured through PISA 2015, namely aspect of knowledge, aspect of competence/process, and aspect of attitude. Based on research conducted by [7] prospective students of Universitas Negeri Semarang especially science teachers still difficult to solve the problems of science laboratory development strategies and the students's weak for having skill to design science laboratory development activities.

Based on this, it is necessary to develop scientific literacy test to measure scientific literacy skills in force subject. The subject on the instruments refers to PISA 2015. The expected that educators can measure the scientific literacy skills of natural science teacher candidate is through the development of this evaluation assessment. Familiarize them with questions of International standard in learning in Indonesia so as to be able to support the improvement of the quality of education in world level, especially in scientific literacy skills.

2. Methods

The research and development is on the development of scientific literacy test. This research refers to the development steps of [8]. Research design which has been three stages, namely: (a) preliminary study phase; (b) development study phase; (c) evaluation phase. The subjects of this study was a science student at Universitas Negeri Semarang in the second semester.

The preliminary study phase included literature studies and interviews. Literature study is done by looking for reference or data related to scientific literacy and scientific literacy skills of natural science teacher candidates. Interviews were conducted to obtain facts and preliminary data for natural science teacher candidates. Furthermore, the development phase includes initial product design, expert validation test, analysis and revision, initial trial, analysis and refinement, until the final product is produced. Evaluation including testing the product in the final trial to the final product is the last stage.

Test validity covers content validity, construct, and concurrent validity. Test validity carried out through instrument review by supervisor 1 as an expert of evaluation field and supervisor 2 as expert of subject matter, while construct validity test was carried out by validation technique by an expert judgment through a validation questionnaire. Concurrent validity is used to determine the correlation between test developed with construct PISA questions using product moment (r_{xy}). Test reliability is done by calculating the reliability coefficient. The characteristic test is done by determining the level of difficulty and distinguishing features.

3. Result and Discussion

3.1. Validity of Evaluation Instrument based scientific literacy

The Validity scientific literacy-based evaluation instruments were carried out before the instrument was piloted in the initial trial to get improvement suggestions. The Content validity test of scientific literacy-based evaluation instrument by experts was obtained very valid with revision. The construct validation test results counted by calculating the score of the validation questionnaire by experts can be seen in Table 1.

Table1.The Result of score the validation of test scientific literacy by experts

No	Aspect	Score(%)			Information
		Expert I	Expert II	Average	
1	Material	85	85	85	Fairly Valid
2	Construction	86	82	84	Fairly Valid
3	Languages	85	95	90	Very Valid
Constructive Validity				86.3	Very Valid

The concluded that the test scientific literacy developed is very valid. The Advice given by experts is that indicators in the grid need to be adjusted to aspects of scientific literacy and the use of effective

sentences. Concurrent validity testing is done using the product moment correlation technique. After data analysis, the results are shown in Table 2.

Table 2. The result of concurrent validity test for scientific literacy

	r_{xy} count	$r_{xy \text{ table}}$ ($\alpha = 5\%$)	Criteria
25	0.676	0.396	Strong

Instruments have strong parallel validity due to several things, including: (1) adequate skills of students; (2) they are in the same relative position in a group when testing with PISA questions and the test of development.

3.2. Reliability of the Evaluation Instrument Based Scientific Literacy

The reliability test was carried out after the trial data of the scientific literacy-based instruments was obtained from 25 test subjects. The reliability test results are presented in Table 3. Researchers tested the product of 50 items test scientific literacy.

Tabel 3. Reliability test results of scientific literacy

N	r_{count}	r_{table} ($\alpha = 5\%$)	Criteria
25	0.71	0.396	High

The results of data analysis indicate that the test scientific literacy is reliable. The reliability coefficients calculated (r_{count}) are greater than the minimum limit reliability coefficient (r_{table}) and in high criteria.

3.3. Characteristics of Test Scientific Literacy

The level of difficulty index (DI) and discrimination power (DP) are part of characteristics of test. The result of calculated DI dan DP showed at Table 4.

Table 4. level of difficulty index and discriminant power

No	DI	DP	Interpretation
1	0.76	0.08	rejected
2	0.92	0.08	rejected
3	0.20	0.24	revision
4	0.24	0.32	received
5	0.28	0.08	rejected
6	0.32	0.16	-
7	0.28	0.24	revision
8	0.40	0.16	-
9	0.32	0.00	rejected
10	0.72	0,64	received
11	0.92	0,24	revision
12	0.84	-0,08	rejected
13	0.76	0,24	revision
14	0.56	0,32	received
15	0.92	0.24	revision
16	0.64	0.32	received
17	0.76	0.08	rejected
18	0.20	-0.24	rejected
19	0.52	0.40	received

20	0.52	0.24	revision
21	0.60	0.72	received
22	0.52	0.08	rejected
23	0.52	0.72	-
24	0.44	0.40	-
25	0.24	0.48	received
26	0.28	0.40	-
27	0.40	0.64	-
28	0.32	0.16	-
29	0.40	0.16	rejected
30	0.16	0.16	-

3.4. Profile of Scientific Literacy Skills of Natural Science Teacher Candidates

Literacy science skills of natural science teacher candidates are measured by analyzing student mastery in each scientific literacy aspect.

3.4.1. Achievement of Scientific Literacy Skills in Knowledge Aspect

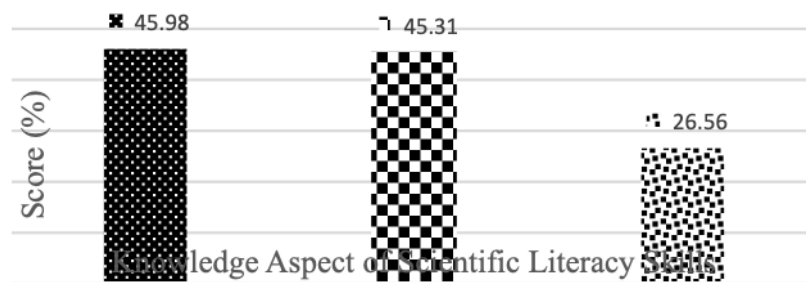


Figure 1. Graph of score percentage in scientific literacy skills aspect of knowledge

Knowledge aspects of scientific literacy skills measured in this study include the content aspect, procedural, and epistemic. Figure 1 presents a distribution of scores on knowledge aspects of scientific literacy skills. Based on Figure 1, it can be seen that in general the achievement of scientific literacy skills in the knowledge aspects of natural science teacher candidate is 39.28% classified as “very less”. The aspects of knowledge (cognitive) gained by students during science learning are important components that determine the level of scientific literacy skills of students [9]. This describes that an understanding of the function and role of learners in justifying knowledge giving birth to knowledge is still less applied in learning and life [10].

3.4.2. Achievement of Scientific Literacy Skills in Competence/Process Aspect

Figure 2 presented a distribution of competency/process aspects of scientific literacy skills score.

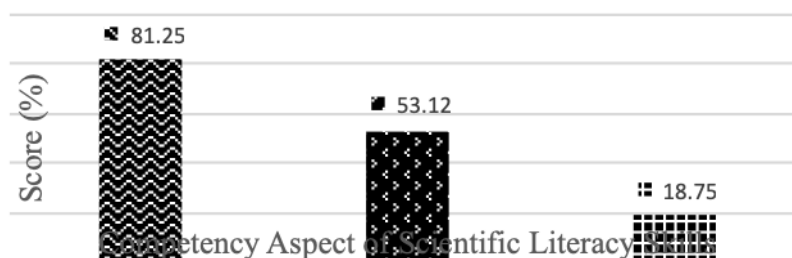


Figure2. Graph of score percentage in scientific literacy skills aspect of competency

Competence/process aspects of scientific literacy skills measured in this study include explaining scientific phenomena (K1), evaluating and designing scientific enquiry (K2), and interpreting scientific data and evidence scientifically (K3). Based on Figure 2, it can be seen that in general the achievement of scientific literacy skills in the competency/process aspects of natural science teacher candidate is 51.04% categorized as “very less”. That students’ skills to explain scientific phenomena and use scientific evidence shows that students have not been able to solve problems scientifically and communicate the result of experiments conducted in writing [11].

3.4.3. Achievement of Scientific Literacy Skills in Attitudes Aspect

Scientific literacy skills of attitudes aspect were measured using a science attitude questionnaire consisting of 32 attitude statements with 5 answer choice adopted using a Likert scale. Table 5 presents the percentage of the average score of a science attitude statement.

Table 5. Percentage of Average Score Science Attitude Statement

Dimensions of Science Attitude Aspect	Number of Questionnaire	Percentage Average Score
S1	1 – 14	74.28
S2	15 – 26	86.61
S3	27 – 32	77.7
Average		79.53

Description:

S1 : interest in science and technology

S2 : assessing everything with a scientific inquiry approach precisely

S3 : understanding and knowing about environmental issues

Scientific literacy skills measured attitudes aspects in this study include interest in science and technology (S1), assessing everything with a scientific inquiry approach precisely (S2), and understanding and know about environmental issues (S3). Figure 3 presents a distribution of scores on science attitudes aspects of scientific literacy skills.

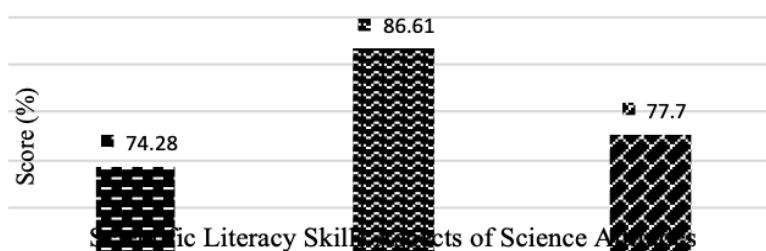


Figure 3. Graph of score percentage in scientific literacy skills aspect of science attitude

Based on Table 5 and Figure 3, it can be seen that in general the scientific literacy skills of science attitudes of natural science teacher candidates is 79.53% classified as “Good”. That one of the factors that influence the achievement of scientific literacy is the aspect of attitudes related to emotions which include the convenience of learning science and involvement of students [12]. The intensity of a student’s motivation will greatly determine their learning achievement [13]. Factors that influence the scientific literacy skills of natural science teacher candidates are summarized into five points as follows: (1) the habit of practicing practicum; (2) the lack of knowledge of science concepts for natural science teacher candidates; (3) the student interest in science teacher candidates for science; (4) experience working on scientific literacy-based evaluation instruments; (5) learning methods used in

the science laboratory [14]. The same thing was revealed by [15] that students of physical geology at the Trinity University of San Antonio Texas also still lack adequate scientific literacy.

4. Conclusion

Based on the results of the research, it can be concluded that the evaluation instrument which developed fulfill the content, construct, and concurrent validity with valid criteria with revision, very valid, and strong validity. Reliability coefficient is 0.71 with a high-reliability category. The proportion of difficulty index test are easy (26.7%), medium (46.4%), and difficult (26.7%) The result of discriminant power obtained good quality (56.7%) and poor quality (43.3%). However, the items still be used because it's adjusted with the test indicator. In general, the profile of scientific literacy skills of natural science teacher candidates is low. The percentage of scientific literacy mastery below 50% for aspects of knowledge and competence. The aspect of the attitude of science gets a good category. The factors that influence the scientific literacy skills of natural science teacher candidates are summarized into five points as follows: (1) the habit of practicing practicum; (2) the lack of knowledge of science concepts for natural science teacher candidates; (3) the student interest in science teacher candidates for science; (4) the experience working on scientific literacy-based evaluation instruments; and (5) learning methods used in the science laboratory.

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