Instrument Development in Measuring the Scientific Literacy Integrated Character Level of Junior High School Students

by Wahab Jufri

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Abstract. The objectives of this study were to develop the scale called the student test of scientific literacy integrated character (SToSLiC), to analyze its validity and reliability, and to portray the primary profile of scientific literacy integrated character of junior high school students in Mataram. The scale was developed in four steps include identifying indicators, developing pool items, checking items validity and reliability, and improving items quality. The scale consists of two parts that are the SToSLiC-A and the SToSLiC-B. The primary pool items of the SToSLiC-A consist of 42 multiple choice items, and 40 Likert-scale items for the SToSLiC-B. The scale was administered to 222 eight graders student in Mataram city. Seven items were eliminated from the initial SToSLiC-A because of the item total correlation were < 0.05 or invalid. Based on item total correlation of the 35 remaining items, the SToSLiC-A was classified as valid (item total correlation coefficient > 0.05), and it has good internal consistency (Alpha-Cronbach coefficient of 0,63). All 40 items of the SToSLiC-B were valid (item total correlations > 0.05) with good internal consistency (Alpha-Cronbach coefficient of 0.87). Based on these values, it can be concluded that the SToSLiC developed in this study provide an objective measure of acquisition of scientific literacy and character of junior high school students.

Keywords: Scale; StoSLiC; Scientific literacy; Integrated-character.

1. Introduction

There has been considerable government investment and policy attention to improve the quality of education. Scientific literacy and strengthening character education have become parts of the main objectives of the elementary and secondary education in Indonesia. Trends in science education policy have emphasized the importance of scientific literacy as a transferable outcome, and development of good character as nurture effects of science education. Scientific literacy and strong character are strategic ways to help students become smart and to help them become good citizens. In this respect, science education is critical for developing students' scientific literacy and character in the same time throughout processes of teaching and learning. Science teacher plays an important role in supporting these efforts. However, the challenge faced by teacher is about how to develop and use instrument to assess scientific literacy and character of the students. Many researchers have developed instrument to evaluate student's scientific literacy [1, 2, 3], but the integrated instrument for assessing scientific

literacy and character is still difficult to be found. Therefore, it is important to provide standardize instrument which then can be used by science teacher in Indonesia.

The purposes of this study are: (1) to develop paper-pencil student test of scientific literacy integrated character (SToSLiC) that would allow researchers and educators to make valid inferences about middle school students' scientific literacy and character; (2) to analyze the test validity and reliability, and (3) to portray the primary profile of scientific literacy integrated character of junior high school students. The SToSLiC developed in this study can help science teachers to assess the student's scientific literacy integrated character. It is also will challenge teachers to provide appropriate teaching methods and learning opportunities that promotes student competences related scientific literacy and development of positive character.

The rest of this paper is organized as follow: Section 2 presents literature review. Section 3 describes the proposed research method. Section 4 presented the obtained results and following by discussion. Finally Section 5 concludes this work.

2. Related Works

Some definitions have been put forward for scientific literacy. In PISA 2006, it was defined as: "…the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity." [4]. Then, in PISA 2009, scientific literacy is defined as the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen [5]. Currently, scientific literacy is interpreted as the ability to read and comprehend science-related articles and also as the capability to understand scientific processes, to apply scientific principles, and to engage meaningfully with scientific information available in daily life [6,3].

Achieving scientific literacy has been proposed as the main goal of science education in many countries [2], as one of the most important skills needed by all young generations in the 21st century [7, 8]. According to [9] reason that higher levels of scientific literacy would tend to increase support for science and provide the public with a more realistic expectation of science education. Therefore, it is important for all stakeholders of education to facilitate the development of scientifically literate young citizens. Some characteristics of scientifically literate person includes: (1) has the ability to make more informed choices, (2) recognize that, science and technology are often a source of solutions and as a source of risk, (3) generate new problems which require science and technology to resolve, (4) consider implications of the application of scientific knowledge and the issues for themselves or the wider society, (5) explain phenomena scientifically, (6) evaluate and design scientific enquiry, and (7) interpret data and evidence scientifically [10, 11].

The Indonesian government is also paying particular attention to the strengthen students' character. It proposes that character development of students as an integral part of school programs. This program has been supported through the Presidential Law Number 87/2017 in which there is stated that character education should be integrated in the intra-curricular, co-curricular, and extra-curricular programs in elementary and secondary school level. Character education program should become the intentional effort to develop core ethical and performance values of students [12]. Character consists of some elements which include specific virtues as a result of the processes of feeling, thinking, and acting in individuals or group of peoples. It is reflected as the unique characteristic of individual or group of peoples which include virtues, moral capacity, and ability, in facing challenges and difficulties in daily lives [13]. It also consists of knowing the good, desiring the good, and doing the good-habits of the mind, habits of the heart, and habits of actions [14]. It was found that student with positive character tend to have higher academic achievement and employees who exhibit consistent positive character are often chosen to lead work teams, receive promotions and gain the trust and admiration of their employers [15, 16]. Thus it is important that educators emphasize character education to develop virtues, quality attributes, personality and leadership in regard of preparing students to enter the 21st century workplace as positively contributing decision-makers [12].

Despite various reforms and research have been undertaken during the last decade in order to increase the quality of science education, students' scientific literacy and character are still facing some problems. Based on PISA test, the scientific literacy of Indonesian student is lower than the average scores of student from other countries [11, 19, 20]. Similar problem is also found for science teacher and student teacher candidates [21].

The main problem for science teacher is that how to construct instrument for measuring students' scientific literacy integrated character. According to [22], assessment of student character is the most important and complex tasks for teacher. Most developed measures draw on some degree of complex knowledge of one or more specific science field or disciplines and most measures do not include assessment of attitudes toward science and development of students' character. Therefore, it will be beneficial for teacher to assess those aspects of education if they are provided with examples of ready to be used instruments, such as proposed in this research.

In order to be able to develop student's character through science teaching, then science teacher should capable of creating suitable learning environment for students. Teachers have to mastering pedagogical knowledge, content knowledge, technological knowledge, and capable of integrating character building into subject's matters. Efforts to strengthen students' character through integrating scientific activities and character education have been proposed by researchers in Indonesia [22, 23, 24]. Through inquiry activities in science classroom, student learn to work together by developing caring relationships, developing good work habits, taking on meaningful responsibilities, and reflecting on life experiences. [24] found that student's learning activities through scientific inquiry can develop scientific literacy and the students' character. Individuals who adopt main values are aware of their responsibilities and they are successful academically [25].

The main problem for science teacher is that how to construct instrument for measuring students' scientific literacy integrated character.

3. Material and Methodology

The SToSLiC has been developed in five phases. ***Phase 1***. *Identifying indicators*. This phase was started by reviewing studies that documented the indicators of scientific literacy and character. To identify these indicators, various existing articles includes [5,11, 3] were reviewed. The scientific literacy indicators used in this study are (1) explain phenomena scientifically, (2) valuate and design scientific enquiry, and (3) interpret data and evaluate evidence scientifically such as used in PISA 2015. The indicators of students' character includes (1) honesty, (2) working hard ethos, (3) self regulated, (4) curiosity, (5) environmental awareness, and (6) responsibility (Perpres, 87/2017). ***Phase 2:*** *Developing pool items*. The pool items candidate of the SToSLiC developed in this study consist of two parts. The first part is called the SToSLiC-A is used to assess the students scientific literacy. It consist of 42 items and are contructed in form of multiple choise question. The second part that is the SToSLiC-B was constructed as Likert scale consist of 40 items to asked for student agreement or disagreement towards the meaning of sentences which express the elements of character education writen in positive and negative forms. ***Phase 3:*** *Checking items validity and reliability*. The content validity of the instruments were performed by experts of science content and three master students enrolled in the Master Program of Science Teacher Education in Mataram University. The SToSLiC was administered for 80 minutes to 222 eight graders students (12–13 years old) in in the first week of March 2018. Those participants come from two junior high schools in Mataram, the capital city of West Nusa Tenggara Provence. One school is located in the central part of the city and the other school is located outside of the city center. The data in this study were analyzed to explore the underlying structure of the test items. The validity and reliability of the test items were statistically analyzed using SPSS computer programs version 16. Validity of the SToSLiC-A was determined by analyzing the item-total correlation, discrimination index, and difficulty index, while its reliability was assessed by Alpha-Cronbach coefficient. For the SToSLiC-B the validity has been subjected by item-total corelation and the reliability accounted by Alpha-Cronbach coefficient. Regarding this, [26] stated that the Cronbach's alpha coefficient is the most used in the assessment of internal consistency,

despite there is no consensus on its interpretation. ***Phase 4**: Improving the items quality*. The final step of the development processes of the SToSLiC was reconstructed the pool items based on the results of validity and reliability analysis. The irrelevant or low quality items have been removed and some were reconstructed or revised for better quality.

4. Results and Discussion

This section presents the results used and the proposed discussion

4.1. Results

The SToSLiC developed in this study consist of two parts. The first part (SToSLiC-A) consists of 42 items which were contructed in form of multiple choise items. The are 14 items for each indicators of scientific literacy. The second part (SToSLiC-B) are constructed in form of 40 Lickert scale items to asked for student agreement or disagreement towards meaning of sentences which express the elements of character education. The agreement or disagreement were represented by a 5-point Likert-scale for positive statements (5 = strongly agree; 4 = agree; 3 = undecided; 2 = disagree; and 1 = strongly disagree). The items consist of 20 pair of sentences, in which the odd numbers are presented in positive statements and the even numbers were writen in negative sentences. The distributions of items in the initial pool of the SToSliC-A and SToSLiC-B are presented in Table 1.

Table 1. Dimension, item mumbers, and item distributions in the SToSliC

	Indicators	Number of items	Distributions
Scientific Literacy Scale (SToSLiC-A)	Explain phenomena scientifically	14	1, **8**, 9,10,11,12, 13, **15**, 20, 28, 29, 31, 37, 41
	Evaluate and design scientific enquiry	14	3, 5, 7, **16**, 22, 23, 24, 25, 26, **32**, 38, 39, **40**, 42
	Interpret data and evaluate evidence scientifically	14	**2**, 4, **6**, 14, 17, 18, 19, 21, 27, 30, 33, 34, 36, 39
Character Scale (SToSLiC-B)	Honesty	6	(2 & 39); (5 & 36); (20 & 21)
	Working habit	8	(6 & 35); (9 & 32); (10 & 31); (15 & 26)
	Responsibility	6	(4 & 37); (8 & 33); (17 & 24)
	Curiosity	8	(19 & 22); (11 & 30); (13 & 28); (16, 25)
	Creativity	6	(12 & 29); (14 & 27); (18 & 23)
	Environmental awareness	6	(1 & 40); (3 & 38); (7 & 34)

The results of statistical analysis which include mean range of the item-total correlations, discrimination and difficulty indexes, and the Alpha-Cronbach values for both of the scales are presented in Table 2.

Table 2. The results of validity and reliability analyses.

	Range of mean (p)	Number of items	Percent of items	Alpha-Cronbach	Item evaluation
SToSLiC-A	0.18 – 0.47 (> 0,05)	35	78 %	-	valid
Item-total correlation	0.10 – 0.18 (< 0,05)	7	22 %	-	not valid
Discrimination index	0.40 – 1.00	21	50%	-	good
	0.30 – 0.39	9	21%	-	reasonably good
	0.20 – 0.29	3	8 %	-	marginal
	< 0.19	9	21%		poor
Difficulty index	0,00 - 0,20	9	21%	-	difficult
	0,21 - 0,70	30	71%	-	medium

	0,71 - 1,00	3	7%	-	easy
Alpha-Cronbach of the pool items	< 0,05	42	100%	0,53	not reliable
Alpha-Cronbach of the valid items	-	35	-	0,63	reliable
SToSLiC-B Item-total correlation	0.13 – 0.58 (> 0,05)	40	100%	-	valid
Alpha-Cronbach of the Character Scale	-	-		0,86	reliable

As can be seen in Table 2, the item total correlation of the SToSLiC-A in this study, range between 0,012 to 0,478, and Alpha-Cronbach coefficient is 0.53. There are 35 (78%) valid items with item total correlation range between 0,18 – 0,88 and $p > 0.05$, and 7 (22%) invalid items. Based on discrimination index, 50% of the items are classified as good, 21% as reasonably good and poor items, and 8% as marginal items. Those 7 invalid items are number 2, 6, 8, 15, 16, 32, and 40. The item total correlation coefficients of those 7 items were less than 0.25. Items number 2, 6, 8, 15, 40 were classified as difficult items with difficulty index < 0.20 and discrimination index < 0.19 or poor items. This means that the pool items of SToSLiC-A was not reliable. [27] suggested that the marginal and poor items can be deleted or improved by revision. However, after these 7 invalid items were deleted, then the Alpha-Cronbach coefficient of the 35 valid items remains to 0,63. On the other hand, the item total correlations of the SToSLiC-B scale range between 0,132 to 0,580 and the Alpha-Cronbach coefficient is 0,87. Based on these values, then the SToSLiC-B can be concluded as valid and reliable without deleted or revised items.

Data obtained from valid and reliable version of the SToSLiC were analysed to portray the profile of scientific literacy integrated character of junior high school students in Mataram as the capital city of West Nusa Tenggara Provence. Score range, mean score, and standard deviations based on each dimension of scientifi literacy and character are presented in Table 3.

Table 3. Number of items, score range, mean, and standard deviation of student's score based on dimensions of scientific literacy and character

	Dimensions	**Number of items**	**N**	**Score Range**	**Mean**	**SD**
Scientific Literacy Scale (SToLS-iC-A)	Total	35	222	0,16 – 0,79	0,46	1,94
	Explain phenomena scientifically	12		0,16 – 0,67	0,46	2,01
	Evaluate and design scientific enquiry	11		0,18 – 0,64	0,43	1,88
	Interpret data and evaluate evidence scientifically	12		0,16 – 0,79	0,51	1,84
Character Scale (SToSLiC-B)	Total	40	222	3,1 – 4,7	4,0	0,41
	Honesty	6		3,7 – 4,5	4,13	0,49
	Working ethos	8		3,5 -4,3	4,00	0,40
	Responsibility	6		2,8 – 4,4	3,79	0,39
	Curiosity	8		3,1 – 4,4	3,92	0,36
	Creativity	6		3,7 – 4,3	4,04	0,45
	Environmental awareness	6		4,1 – 4,7	4,17	0,40

Data in Table 3 shown that the mean score of students scientific literacy for the evaluate and design scientific enquiry, explain phenomena scientifically, interpret data and evaluate evidence scientifically dimensions were 0,43, 0,46 and 0,51 respectively. Based on mean score of total items (0, 46), it can be seeen that only 46% participant students can answer the SToSLiC-A correctly. It means that the level of scientific literacy of junior high schools in Mataram can be categorized as low. The average score of student's character from six dimensions (honesty, working ethos, responsibility, curiosity, creativity, and environmental awareness) range from 3,79 to 4,17. Based on these data, it can be conclded that character (cognitive-character) of the students are in good category. Figures 1 and 2 below show the levels of student scientific literacy and character based data from SToSLiC-A and SToSLiC-B which have been developed in this study.

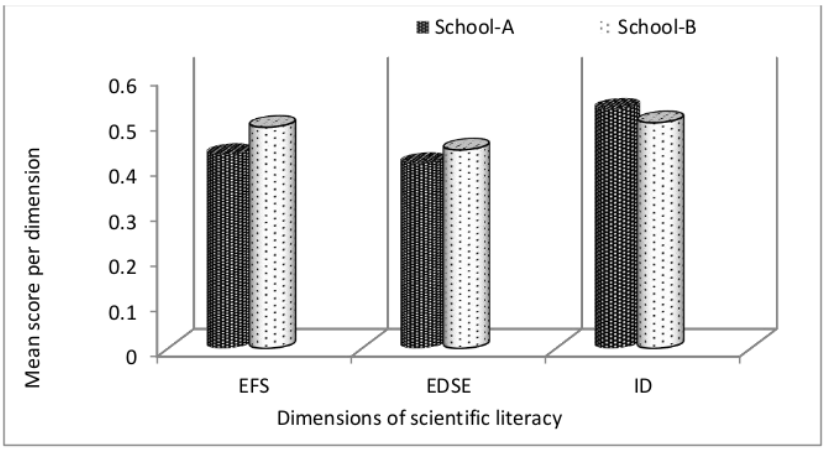

Figure 1. The mean score of student's scientific literacy for each dimension (EFS : explain phenomena scientifically, EDSE: evaluate and design scientific enquiry, ID: interprete data).

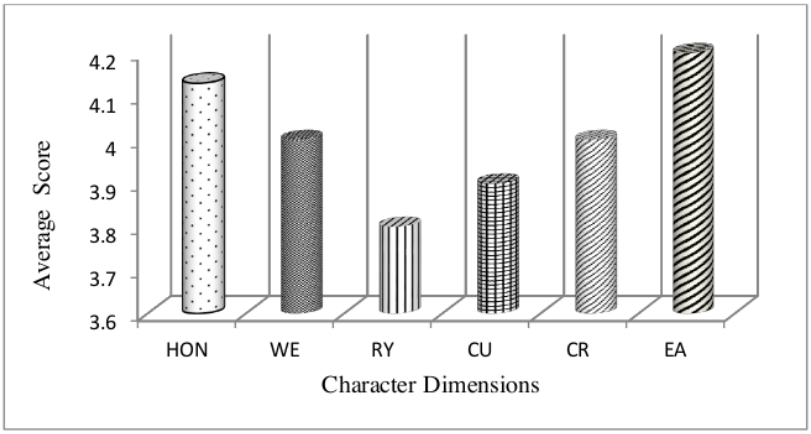

Figure 2. Average score of each dimension of students' character (HN: honesty, WE: working ethos, RY: responsibility, CU: Curiosity, CR: Creativity, EA: Environmental awareness)

4.2. Discussion

Achieving high level of students' scientific literacy and development of their strong positive character should become main objectives of science education. To assess scientific literacy and character of junior high school student, it is important for science teachers and researchers to develop qualified instruments. This research was an attempt to design and develop an instrument called the student test of scientific literacy integrated character (SToSLiC). This is subjected to assess the scientific literacy and positive character of junior high school students. The instrument consists of two parts. Part A is so called the SToSLiC-A consisted of 35 multiple-choice items and the SToSLiC-B consist of 40 items constructed in Likert-scale.

Development of the SToSLiC was started with literature review and establishing the pool items candidate. According to [28] the literature review is very important because it will serve to clarify the nature and range of the content of the target construct, may help to identify problems with existing measures that can be avoided, and a thorough review will indicate whether the proposed scale is actually needed. Following the first step in establishing the SToSLiC, then it was validated by expert and two experiences science teacher education with objectives to gather the content validity. The other steps were to conduct field trial test, analyze validity and reliability, and then revising or reconstructing the pool items to establish the final form of the SToSLiC. These processes have been undertaken in order to strengthening the quality of the instrument. Concomitant to this process, [29] stated that instrument should has several practical requirements such as (1) can measure value added by the instruction and must be possible to administer in pre- and post-instruction basis, (2) easy to administer and grade in the context of a normal course schedule without any training, and (3) needs to be demonstrated that instrument measures what it claims or evidence of validity. Therefore, establishing items validity is an important part of the process of instrument development.

As the value of item total correlations of the SToSLiC-A final pool is more than 0,25 ($p > 0.05$) and that of the SToSLiC-B more than 0,60, then the SToSLiC is valid. In this case, Tezbaşaran as cited by [30] stated that item total correlation coefficients of instrument should be positive and at least 0.25. The Alpha-Cronbach coefficient of the SLoSLiC-A and the SToSLiC-B are 0.63 and 0.87 consecutively, therefore the scale developed in this study can be concluded as reliable. In regard to reliability of the scale, [31] stated that general accepted rule is that α of more than 0.6 indicates an acceptable level of reliability. Therefore, the findings in this study depicts that the SToSLiC scale is reliable and homogenous to access secondary school students acquisition of scientific literacy and integrated elements of character education [27].

The total mean score of student's scientific literacy was 0,46 which means that 64% or more than 50% of the test items in SToSLiC-A did not correctly answered by the students. Based on numerical classification, the average score falls in nominal and functional level. If analogues to the proficiency levels that is a description of knowledge and skills they can displayed, scientific literacy of the participant students in this study is classified in level 3. Student in nominal level of scientific literacy has some misunderstandings, naive theories and are able to demonstrates limited terms. While students with the functional level of scientific literacy is characterized by the ablity to use scientific vocabulary, defines terms correctly in particular situations, and mostly memorizes scientific responses from textbook, and plays a role as a consumer of sciencitific and technological products [32]. According to [33] student in proficiency level 3 are able to identify clearly described scientific issues in a range of contexts; select facts and knowledge to explain phenomena and apply simple models or inquiry strategies; interpret and use scientific concepts from different disciplines and apply them directly.

Currently, scientific literacy has been interpreted as the capability to understand and to apply scientific principles in everyday life, which then will appear as student attitudes, will leads to habits on mind, habit to do, and finally can build the students' character [6, 24]. Integration of science and character education teaches the habits of thought and deed that help people live and work together as friends, colleagues, communities and nations. Implementation of character education has been found

support the quality of student academic achievement [15]. This fact has a great appeal for supporting the government program to promote student scientific literacy and strengthening students' character. In order to facilitate development of student's scientific literacy with positive character, then science teacher must be able to practice the science literacy competences and also practice indicators of positive character in their daily life. When teachers and students address scientific literacy in context of character education, then they will experience the complexity of science and technology from a personal and social perspective. It was found that individuals who exhibit consistent positive character are often chosen to lead work teams, receive promotions and gain the trust and admiration from others [16]. Therefore, strengthening student's character is an essential component to preparing students to enter the 21st Century workplace. To facilitate the development of scientific literacy and positive character of junior high school student, therefore, science teacher must be able to teach science as scientific processes through inquiry models of teaching and learning activities. In this regards, [32] stated that scientific literacy is best taught by seeing science education as an education through science as opposed to science through education. Regarding the important of science literacy and character education, then science teachers needs to prepare appropriate evaluation tools or instruments to assess the development of student's scientific literacy and character such as work habit, curiosity, creativity, honesty, and responsibility [34, 35]. The SToSLiC developed in this study will be part of valuable instruments for measuring the quality of education that can be used or adopted by science teacher and researcher especially in the field of scientific literacy and character education.

5. Conclusion

The SToSLiC developed in this study has proven to be valid and reliable. It could be a useful instrument for researchers and science teachers for investigating development of scientific literacy and character buildings of year 7 to year 9 students in elementary school. The proficiency level of students' scientific literacy is classified as low and their character is categorized as good. This information could guide science teachers in refocusing their teaching practices and provide opportunities for the development of students' scientific literacy and strengthens their positive character. Moreover, for researchers, this scale can be used as one of standardized instruments to help overcome the problems of science education quality. Finally, an interesting direction for further work is developing student resources and teaching strategies that can be implemented by science teachers to develop students' academic achievement and strengthen students' character.

Acknowledgement
This research is fully supported by the Ministry of Research, Technology, and Higher Education under Grant Agreement No. 796/UN18.L1/PP/2018. The authors would like to thanks Ministry of Research, Technology, and Higher Education and Rector of the University of Mataram.

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