STEM learning on environmental pollution topic: identifying science self-efficacy instrument using Rasch model analysis

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Abstract. The instrument was made as an effective way to measure students’ science self-efficacy in a particular topic such as environmental pollution during the implementation of STEM Learning. A sample of 65 students grade 8th near West Java was involved in this study. The instrument consists of 28 statements, which are divided into six aspects of science self-efficacy which are conceptual understanding, high order cognitive skill, everyday application, science communication, physiological state, and practical work. The process of developing instrument consists of several steps: (1) conduct literature review, (2) construct students’ science self-efficacy, (3) validity and readability test, and (4) conduct test. Rasch Analysis Model is used to analyze the data using version 4.4.5 of the Winstep Application. The result shows Cronbach’s alpha value is 0.91, which means the interaction between items and the person as a whole is in a very good category. It could be used as an instrument for another implication.

1. Introduction

In the 21st century, it requires specific skills and technical assistance throughout the various fields of life to cope with the complexities in the current world [1]. The expertise of 21st-century skills, therefore, needed to integrate into the existing framework of the education system [2]. So, STEM education will help students prepare themselves for this global change to address the challenge [3].

STEM learning provides an inclusion into one shared learning experience of two or more subjects. The integration of science and mathematics has reported on the attitudes and involvement in school [4]. Besides that, the integration of several topics in the following lessons may adversely impact the students’ learning outcomes and motivation [5]. STEM education could even lead to new ideas, products, or knowledge across subject areas in comparison to practical activities [6,7]. The incorporation of science and mathematics is not enough, thus add technology and engineering aspects is a key to reach successful STEM learning [8].

The implementation of STEM learning attempts to encourage more skill to real-life issues and concentrates on more practical tasks. The environmental pollution problem is one of the topics in science subjects used as the implementation of STEM Learning. However, students can seek approaches to real-world issues by analyzing, designing, constructing, testing, and redesigning processes [9] to develop new technology for solving the problem. Students require opportunities to develop procedures or products for meaningful learning to take place. The findings found that students who are generally not interested in science participated actively in the design process [10].
Thus, a strong belief within each student is necessary to complete the project given. These factors can be found in students’ self-efficacy. It is assessed as the beliefs of people regarding their willingness to organize and complete a task that is needed to achieve individual results[11]. Primarily, self-efficacy plays a part in determining the selection of activities and environments, expenditure on effort, persistence, thinking patterns, and emotional responses when confronted with challenges [12]. However, the self-efficiency of each student is different. This is reinforced by the previous research of science self-efficacy in biology class. The data shows that there are 29 students in average class score intervals, 31 students scored below average, and 25 students scored above average [13]. Another findings, the average science self-efficacy rate of the students was 3.39, while academic outcomes rates of the students reached only the minimum level [14]. Within the same study, individuals with high self-effectiveness are seeking to do more than people who have low self-effectiveness.

The level of adequate self-actuation measures that greatly influence STEM career selection as this efficacious trait is not adequately targeted, and the educators lose the chance to intervene early [15]. Due to the sources of the limitations of reference to science self-efficacy on specific subjects and student level of education, the authors intend to develop instruments to measure science self-efficacy to be implemented in science STEM learning.

Many ways can be used to process data. Generally, previous research in analyzing the results of science self-efficacy data uses the SPSS application to determine validity and reliability [16,17]. Another alternative to analyze the data of educational research is using Rasch Analysis Model. The benefits of using the Rasch Analysis model provide a lot of details on each item also the information of the person. Winsteps’s Rasch model offers researchers in education or another applied scientific area the most valuable and reliable data for the assessment in products and tests. [18]. It enables researchers to create other measurement tools, which allows the instrument to be modified because of student change and progress [19].

Based on the consideration of the problems presented, the science self-efficacy instrument will be covered six aspects during the implementation process. Due to the sources of the limitations of science self-efficacy on specific subjects and student level of education, the authors intend to develop and validated instruments to measure science self-efficacy to be implemented in STEM learning. Particularly for junior high school students in the environmental topic.

2. Methods
This research has several steps: (1) conduct literature review, (2) construct student’s self-efficacy, (3) validity and readability test, (4) conduct test. The study included 65 students in 8th grade Junior High School who came from several West Java schools. Convenience sampling is used as the sampling technique in this research. The convenience sample is the individuals who are available or convenient to be studied [20].

There were 28 statements used to measure science self-efficacy, which are distributed over six dimensions, such as conceptual understanding, high order cognitive skill, everyday application, science communication, physiological state, and practical work. Each statement is given a response choice in the form of strongly agree, agree, disagree, and strongly disagree in the way of a four-point Likert scale. The data obtained are then analyzed using version 4.4.5 of Winsteps. Analysis of validity and reliability conducted using the Rasch analysis model.

3. Result and Discussion
The study findings and discussion are divided into four sections: 1) Constructing science self-efficacy instrument, 2) Reliability of the instrument, and 3) Validity of the instrument.

3.1. Constructing science self-efficacy instrument
Due to the limited tools available for measure self-efficacy in science education, developing instruments for this variable is deemed important. Particularly, for environmental pollution topic. Researchers need a valid and reliable test to determine the efficiency of various educational activities. The process of constructing instruments to assess science self-efficacy in environmental topic involves several steps; Readability tests are initiated by conducting a literature review on self-efficacy, science self-efficacy
and environmental pollution which was given to 5 eighth grade students and reviewed by items by 3 expert content and the last conduct test for 65 junior high school students to find a reliability value. Aspects are shown in table 1 when constructing an instrument.

**Table 1. Science self-efficacy blueprint**

| Aspects                        | Indicators                                                                 | Question’s Number |
|--------------------------------|-----------------------------------------------------------------------------|-------------------|
| Conceptual understanding       | Identify the capacity of students for using cognitive essential skills, including scientific principles, laws or theories | N1, N2, N3, N4    |
| High order cognitive skill     | Evaluate the willingness of students to apply advanced cognitive skills along with solving problems, critical thinking, or scientific analysis | N5, N6, N7, N8, N9 |
| Everyday application           | Evaluate the ability of students applying scientific ideas and associated abilities in everyday life | N10, N11, N12, N13, N14, N15 |
| Science communication          | Identify the participants’ skill of scientifically, communicating or discussing with others | N16, N17, N18, N19, N20, N21 |
| Physiological state           | Identify behavioral and physiological problems of students, such as science stress, depression or anxiety particularly in STEM learning | N22, N23, N24, N25, N26 |
| Practical work                | Identify students’ confidence in their ability to accomplish practical activities of STEM learning in both cognitive and psychomotor domains | N27, N28 |

Thereby, 28 statements for science self-efficacy questionnaires are derived from the number of each aspect. The authors used the 4-point Likert Scale to answer the statements given: strongly disagree (1), disagree (2), agree (3), and strongly agree (4). This instrument needs to go through the readability phase before the validity test is carried out. The readability test has been tested on 5 students in grade 8th. The category is to ensure whether the statement is easy to understand and there are no words or terms that can make students confuse. An appraisal is also seen in the appropriateness of the item written with the
discovered aspects and adequacy of the language used who carried out by 3 expert judgments that are appropriate in their field.

3.2 The validity of science self-efficacy instrument

The criteria used for determining item validity using Rasch Analysis Model based on the Outfit Mean Square (MNSQ), Z-Standard Outfit (ZSTD), and Point Measure Correlation (Pt Mean Corr) [21]. Identification value that can be accepted are Outfit Mean Square (MNSQ) value that can be accepted: $0.5 < \text{MNSQ} < 1$, Outfit Z-Standard (ZSTD): $-2 < \text{ZSTD} < +2.0$, Point Measure Correlation (Pt Mean Corr) $0.4 < \text{Pt Mean Corr} < 0.85$. The data analysis for the validity of its items can be seen in Figure 1.

| Item | INFIT MNSQ | OUTFIT MNSQ | PTMEASUR-AL CORR. | OBS% | EX% |
|------|------------|-------------|-------------------|------|-----|
| N12  | 3.85       | 1.82        | 4.05              | .9   | 56  |
| N9   | 1.01       | .82         | -.06              | .70  | 56  |
| N28  | 1.01       | 1.81        | .12               | .56  | 61  |
| N9   | .95        | .95         | -.22              | .57  | 67  |
| N5   | .93        | .93         | -.38              | .57  | 64  |
| N27  | .93        | .92         | -.41              | .56  | 59  |
| N3   | .94        | .92         | -.48              | .51  | 53  |
| N7   | .87        | 1.08        | .51               | .56  | 47  |
| N21  | .71        | .79         | 1.96              | .60  | 61  |
| N20  | .72        | .71         | .12               | .62  | 58  |
| N25  | .88        | .87         | -.73              | .52  | 61  |
| N23  | 1.16       | 1.14        | .83               | .42  | 56  |
| N26  | 1.02       | 1.10        | .21               | .55  | 61  |
| N15  | 1.18       | 1.19        | 1.05              | .48  | 53  |
| N18  | .86        | .79         | .41               | .61  | 53  |
| N22  | 1.21       | 1.21        | 1.18              | .43  | 63  |
| N17  | .61        | -2.61       | .61               | .66  | 70  |
| N16  | .64        | -2.32       | .63               | .69  | 72  |
| N2   | .89        | -1.58       | .90               | .58  | 67  |
| N13  | .61        | -2.58       | .61               | .64  | 69  |
| N4   | .91        | -4.77       | .90               | .68  | 61  |
| N24  | 1.14       | .85         | 1.12              | .57  | 61  |
| N11  | 1.32       | 1.77        | 1.29              | .36  | 58  |
| N19  | .66        | -2.18       | .67               | .57  | 66  |
| N9   | .81        | -1.17       | .89               | .57  | 69  |
| N1   | .57        | -2.20       | .64               | .65  | 78  |
| N14  | 1.89       | 4.33        | 1.85              | .28  | 45  |
| N10  | 2.30       | 5.51        | 2.08              | .25  | 41  |

**Figure 1. Item measure**

Based on data present in Figure 1, there are 22 items valid and 3 items in the yellow-highlighted at the picture (N16, N13, and N1) need to revise because there are one from three aspects whose value exceeds or is less than the provisions mentioned above to be said to be a valid item. For examples in items N13, the initial statement stated about social issues in the environment about the acidification phenomenon. But, the statement was modified as its sea acidification phenomenon was considered too confusing and replaced by the poor quality of water phenomenon for junior high school students so they easy to understand.
The item number N12, N14, and N10 were deleted as can be seen in the Figure 1 with green-highlighted. Most of the statement indicates to deceive students because if the student was not careful it was likely that the statement would be incorrect. Overall, the item was deleted because the values were too greater or smaller than the third provisions provide.

a. Reliability of science self-efficacy instrument
The findings obtained from the questionnaire responses are analyzed to find the reliability of science self-efficacy. Rasch Analysis Model shows to what extent students possess the ability as well as certain psychometric properties of evaluation methods [22], can be seen from the figure below.

![Figure 2. Reliability test](image)

From figure 2, the reliability of the self-efficacy instrument using Winsteps application obtained a person reliability value of 0.89 it categorized as good criteria with a separation group value of 2.91 in blue-highlighted and item reliability for about 0.93 that shows very good criteria according to the criteria above with a separation group value of 3.62 at orange-highlighted. The greater value of separation, the quality of the instrument of all respondents and items will better because it can identify the groups of respondents and items. Cronbach's alpha value is 0.91 at green-highlighted, which means the interaction between items and the person as a whole is in a very good category.
4. Conclusion
It can be concluded that the results of the instrument development can be utilized by all parties who will take measurements related to science self-efficacy in future studies. The results of the validity and reliability tests indicate that science self-efficacy is feasible for use. The result of that construct validity examination showed 22 items are valid and 3 items need to revise from 28 items. The overall reliability value (Cronbach Alpha) is 0.91 indicates to a good category.

It is very helpful to predict the students’ belief to be able to participate in science class particularly in STEM learning for environmental pollution topics. Also, it is very important to understand the self-efficacy of students to support their readiness to deal with the problem given and complete the hands-on activities.

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