Validity and Reliability of Assessment Instruments for Analytical Thinking Ability and Chemical Literacy in the Colligative Properties

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Abstract. This study aimed to develop and determine the construct validity, reliability, and items analysis of the instruments for assessing analytical thinking abilities and chemical literacy in the colligative properties materials. This study was a research and development (R&D) utilizing the ADDIE model. The subjects of this study were 30 students of class XII at senior high school (SMA) in Bengkalis. The results revealed that of the 15 items on the analytical thinking skills and chemical literacy, 10 items had good construct validity and had very high reliability test values, with the Cronbach alpha of 0.887. The results of item analysis of the instrument which was developed for assessing the analytical thinking skills and chemical literacy showed that for the difficulty indices, 80% of the items were classified as moderate items and 20% of them were classified as easy items. Then, the analysis results for the discrimination indices revealed that 80% of the items were good while 20% of the items were categorized as satisfactory. In addition, based on the analysis of construct validity, reliability, and items analysis, the assessment instrument for analytical thinking ability and chemical literacy was valid and feasible to be used to measure the students’ analytical thinking skills and chemical literacy on the material of colligative properties on a broad scale test.

1. Introduction
Learning is an activity that has an important role in realizing the quality of education [1]. The biggest challenge in education in the global era is the improvement of students’ thinking abilities. In the 21st century, the development of students’ competence does not only focus on academic development, knowledge, and independence but also produce students who are innovative, creative, effective and skilled in solving problems [2]. Therefore, developing the students’ thinking skills is very crucial. The characteristics of higher order thinking skills are identified as analysis, evaluation, and creating skills in the learning process [3]. Whereas learning process includes planning, implementing, evaluating learning outcomes, and following up. Effective and efficient learning will not succeed without a good judgment. The process of learning and evaluating learning outcomes is an integral part that cannot be separated.

Assessment can provide information that can enhance students’ knowledge in learning and that can help teachers in teaching [4]. Appropriate assessments can produce accurate data about learning success and are used as a basis for determining a follow-up. The assessment system is defined as a process of gathering and processing information to determine the achievement of students’ learning outcomes in accordance with the Minister of National Education Regulation No. 20 of 2007 concerning educational assessment [5]. Assessment is an important component in the administration of education because efforts to improve the quality of education can be pursued through improving the
learning and the quality of the assessment system [6]. Assessment is expected to reflect the overall abilities of students in aspects of knowledge, attitudes, and skills [7]. Thus, assessment is designed and implemented by the teacher based on the planning and implementation of learning activities.

Sastrawijaya [8] states that learning chemistry aims to foster scientific attitudes in daily life, to gain a long-lasting understanding of various facts, to have skills in using laboratories and the ability to recognize and solve problems. One of the abilities the students need to optimize in the 21st century learning is the ability to think analytically. In addition, one of the abilities the students need in learning chemistry is the ability of chemical literacy since chemistry is loaded with concepts, facts, and contextual aspects of daily life. To date, the assessment activities carried out by teachers are generally only to measure cognitive aspects.

In addition, at the end of learning, the teacher commonly measures low-level cognitive aspects as an evaluation to learning outcomes. In this case students do not have the opportunity to improve their ability to think of high-level cognitive thinking optimally. Besides, the students’ chemical literacy abilities can be stimulated in the activities of assessing learning outcomes. During the process of learning chemistry, questions given to the students only aim to identify the students’ comprehension and only focus on the materials conveyed in the learning process and in textbooks. Some problem-based questions are rarely emphasized, for example questions that require the ability to think critically, think analytically and solve problems [9].

The ability of thinking analytically is very necessary for students to enhance meaningful learning because analytical reasoning is the basic ability used in solving problems in various fields [2]. If students have good analytical thinking skills, they will be ready to face challenges in everyday life in the future. Whereas scientific literacy is the ability to use scientific knowledge, to identify questions, and to demonstrate scientific facts based on conclusions in order to understand and make decisions about the universe that influences social life [10].

Moreover, assessing the learning outcomes is not only identical with cognitive learning outcomes but also requires students’ thinking skills in accordance with the contents of the 2013 curriculum which requires teachers to be able to develop students' thinking skills; some of which are analytical thinking and chemical literacy [11]. Based on the basic competence of the material about colligative properties stated in the 2013 curriculum, students are expected to be able to achieve the analyzing process (C4) and the material about colligative properties contains concepts, facts, and is contextual to everyday life (chemical literacy). Hence, the assessing the learning outcomes can be conducted by utilizing the instruments that can measure the ability from both aspects.

To facilitate the process of assessment on the material about colligative properties, teachers need an instrument that can measure both aspects of student ability which is known as an integrated assessment. Integrated assessment can measure analytical thinking ability and chemical literacy in one question at one time. The questions must be based on learning indicators, analytical thinking indicators, and indicators of chemical literacy. Thus, in developing an assessment instrument, a researcher should analyze the characteristics of the instrument such as the content and construct validity, reliability, difficulty indices, and discrimination indices in order that the instrument can function properly to measure students’ abilities. In this study, the researchers analyzed the construct validity, reliability, difficulty indices, and discrimination indices of the assessment instrument developed. Then, the content/material and measurement aspects of analytical thinking ability and chemical literacy were validated by expert validators.

2. Methodology
This study was an R&D research using ADDIE development model. This model consists of analysis, design, development, implementation, and evaluation. This study was quantitative research which utilized a descriptive quantitative method. The development process began with the phases of needs analysis, problem analysis, as well as the analysis of learning indicators, analytical thinking indicators, and chemical literacy indicators. Then, the product was designed by considering the test objectives, targets, grids, and scoring guidelines. The researcher set 15 questions based on the test grid designed at the previous phase at the development stage, the researchers developed the product, in this case, creating 15 question items and compiling the scoring guidelines. After developing the instrument, it
was validated by 3 lecturers as the material experts. Then, the items of questions that had been validated and declared valid were analyzed at the implementation stage. The researchers also conducted an initial trial for the instrument to 30 high school students in class XII at this stage. The results of the initial trial were then analyzed in terms of its construct validity, reliability, difficulty indices and discrimination indices.

In this study, the construct validity was determined by using Pearson product moment correlation formula. If the correlation value > 0.36 at the significance level of 5%, the instrument could be said valid. Then, the reliability of the questions was tested by using Cronbach Alpha statistical test. Instruments with a Cronbach alpha value > 0.6 were declared reliable and feasible. At last, items analysis was conducted to determine the difficulty indices and discrimination indices of the items. After that, the researchers conducted limited tests and wide-scale tests.

In this article, researchers presented the results of the study which were limited to the results of the analysis of construct validity, reliability and item analysis (difficulty indices and discrimination indices). The results of a good items analysis determined whether the instrument would be able to function according to the aspects to be measured on a broad scale.

3. Results and Discussion

3.1 Testing the Construct Validity

Construct validity was tested by analyzing the results of the answers from 30 students at the initial trial by using Pearson Correlation formula with SPSS 20 application. After obtaining the results of Pearson correlation items, the value of calculation correlation (r calculated) was compared with r table with a significance level of 5% and df=N-2 [12]. The Pearson correlation of items validity is shown in table 1.

| No | R<sub>calculated</sub> | Categories |
|----|-----------------|-------------|
| 1  | 0.329           | Invalid     |
| 2  | 0.716           | Valid       |
| 3  | 0.653           | Valid       |
| 4  | 0.730           | Valid       |
| 5  | 0.808           | Valid       |
| 6  | 0.178           | Invalid     |
| 7  | 0.725           | Valid       |
| 8  | 0.702           | Valid       |
| 9  | 0.609           | Valid       |
| 10 | 0.727           | Valid       |
| 11 | 0.217           | Invalid     |
| 12 | 0.689           | Valid       |
| 13 | 0.713           | Valid       |
| 14 | 0.199           | Invalid     |
| 15 | 0.091           | Invalid     |

The analysis result of Pearson correlation revealed that 10 of the 15 items analyzed were found to be constructionally valid, including the items with a correlation value > 0.36, it was stated that if the validity correlation < 0.36, the items were constructionally invalid so the questions were not used/discarded. The items declared invalid were items number 1, 6, 11, 14, and 15.
The distribution of 15 items based on the validity index is displayed as follows:

| No | Validity Index | Items Number                  | Number of Questions | %  |
|----|---------------|-------------------------------|---------------------|----|
| 1  | >0.36         | 2, 3, 4, 5, 7, 8, 9, 10, 12, 13 | 10                  | 67%|
| 2  | <0.36         | 1, 6, 11, 14, 15              | 5                   | 33%|

3.2 Testing the Reliability

The reliability testing was carried out on 10 items that had been declared valid by using Cronbach Alpha correlation for 30 test subjects. The results of the reliability analysis of the items are shown in table 3.

| Cronbach's Alpha | N of Questions |
|------------------|----------------|
| 0.887            | 10             |

Based on the analysis results, the reliability of the instrument > 0.6 (minimum limit of Cronbach Alpha), so it can be concluded that the instrument developed for analytical thinking ability and chemical literacy was reliable.

3.3 Items Analysis of the Assessment Instrument

In this study, the items analysis of the instruments for assessing analytical thinking abilities and chemical literacy included difficulty indices and discrimination indices [13]. The results of the interpretation for difficulty indices and discrimination indices of this instrument are shown in table 4.

| Items Number | Difficulty Indices | Discrimination Indices | Interpretation      |
|--------------|--------------------|------------------------|---------------------|
| 2            | 0.625              | 0.46875                | Moderate, Good      |
| 3            | 0.633333           | 0.40625                | Moderate, Good      |
| 4            | 0.7                | 0.40625                | Moderate, Good      |
| 5            | 0.766667           | 0.46875                | Easy, Good          |
| 7            | 0.483333           | 0.59375                | Moderate, Good      |
| 8            | 0.55               | 0.5                    | Moderate, Good      |
| 9            | 0.741667           | 0.375                  | Easy, Satisfactory  |
| 10           | 0.725              | 0.375                  | Easy, Satisfactory  |
| 12           | 0.533333           | 0.46875                | Moderate, Good      |
| 13           | 0.541667           | 0.59375                | Moderate, Good      |
Based on table 4, it was found that 3 items of 10 items being analyzed were categorized as easy items while 7 items were categorized as moderate items. Based on this result, no item was categorized as difficult items. Then, the analysis results of the discrimination indices indicated that 8 items were classified as good items and 2 items were classified as satisfactory items. The results of the difficulty indices are shown in table 5.

### Table 5. Results of Difficulty Indices of the Items

| Criteria of Difficulty Indices | Difficulty Indices Index | Items Number | Number of Questions | % |
|--------------------------------|--------------------------|--------------|---------------------|---|
| Easy                           | 0.71-1.00                | 5, 9, 10     | 3                   | 30 % |
| Moderate                       | 0.31-0.70                | 2, 3, 4, 7, 8, 12, 13 | 7 | 70% |
| Difficult                      | 0.00-0.30                | -            | -                   | 0 |

According to Nana Sudjana [14], there are three categories of difficulty indices: easy, moderate, and difficult. He argues that a good difficulty indices has a value between 0.25 – 0.75. Questions with the difficulty index below 0.25 are categorized as difficult items and questions with the difficulty index above 0.75 are categorized as easy items. Thus, the questions for assessing analytical thinking skills and chemical literacy in this study can be categorized as good because it has a value between 0.40 – 0.76.

Moreover, the distribution results of discrimination indices are shown in table 6.

### Table 6. Analysis Results of Discrimination Indices

| Criteria of Discrimination Indices | Discrimination Index | Items Number | Numbers of Questions |
|-----------------------------------|----------------------|--------------|----------------------|
| Excellent                         | 0.71 - 1.00          | -            | -                    |
| Good                              | 0.41 - 0.70          | 2, 3, 4, 5, 7, 8, 12, 13 | 8 |
| Satisfactory                      | 0.21 - 0.40          | 9, 10        | 2                    |
| Poor                              | 0.00 - 0.20          | -            | -                    |

Table 6 demonstrates that 80% of the items are categorized as good items while 20% of the items are categorized as satisfactory items. Moreover, there is no item categorized as excellent and poor items. Overall, the questions are categorized as good items indicating that they have the ability to distinguish between high level students (those who understand the materials well) and weak students (those who do not understand the materials).

Based on the analysis result, it was found that the construct validity, reliability, and items analysis of instrument was valid, reliable and had good items. Thus, the questions could be used as an instrument to assess the students’ analytical thinking and chemical literacy for the material of colligative properties.

### 4. Conclusion

Based on the description above, it can be concluded that the instrument for assessing analytical thinking ability and chemical literacy that was developed in this study fulfilled the correlation of construct validity and the Cronbach alpha value of 0.887 with the very high category. Then, the difficulty index of the questions was between 0.40 and 0.76 with good category. Furthermore, 80% of
the items had good discrimination indices while 20% of the items were declared satisfactory. Thus, the assessment instruments are declared valid and feasible to be used in wide-scale tests to measure the students’ analytical thinking skills and chemical literacy for the material about colligative properties.

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