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# Opportunity Integrated Assessment Facilitating Critical Thinking and Science Process Skills Measurement on Acid Base Matter

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**Abstract.** Recognizing the importance of the development of critical thinking and science process skills, the instrument should give attention to the characteristics of chemistry. Therefore, constructing an accurate instrument for measuring those skills is important. However, the integrated instrument assessment is limited in number. The purpose of this study is to validate an integrated assessment instrument for measuring students' critical thinking and science process skills on acid base matter. The development model of the test instrument adapted McIntire model. The sample consisted of 392 second grade high school students in the academic year of 2015/2016 in Yogyakarta. Exploratory Factor Analysis (EFA) was conducted to explore construct validity, whereas content validity was substantiated by Aiken's formula. The result shows that the KMO test is 0.714 which indicates sufficient items for each factor and the Bartlett test is significant (a significance value of less than 0.05). Furthermore, content validity coefficient which is based on 8 experts is obtained at 0.85. The findings support the integrated assessment instrument to measure critical thinking and science process skills on acid base matter.

## INTRODUCTION

Nowadays, we are in the area of science and technology where scientific knowledge has grown exponentially and technology has progressed at rapid pace. Science education plays a major role for the futures of societies. Globally, countries have continuously sought to improve the quality of science education particularly developing countries. Based on Indonesian Law number 20/2003 the government construct curriculum to produce human resources who are productive, creative, innovative, and affective throughout attitude, skills, and knowledge in integrated manner [1]. Therefore, school should enable students to integrate their knowledge with problems in daily life. Those potency can be materialized if the science learning process can grow students' critical thinking and science process skills, so do chemistry as a part of science.

Recognizing the importance of science process skills, lately several studies related to that has been done. Science process skills could use in each step of students' life by being scientifically literate by comprehending the nature of science. Therefore, science process skills are necessary tool to produce and use scientific information, to perform scientific research, and to solve problems [2]. It is more important for the students to learn how to apply science than learning reality, concepts, generalizations, theories and laws in science lessons [3]. Science process skills should be applied to students because indirectly involving them in various inquiry activities. In addition, it is able to direct them to apply both basic and integrated science process skills [4].

Critical thinking skills are essential part of the process of scientific investigation, especially the analysis and evaluation of scientific evidence [5]. In the other words, science process skills have correlation with critical thinking skills because it has a close relationship with the mastery concept [6]. Some scholars and educators erroneously assume critical thinking to be higher order thinking [7]. Therefore, it is important to develop science process skills to ensure student master the concepts taught well. Upon the statements of experts, students should be prepared to cope with this world with higher level skills involving critical thinking and science process skills, so that they can solve problems in education learning and other fields.

Assessment is an integral part of the learning process. It provides an operational definition of standards, in that they define in measurable terms what teachers learn. When students engage in assessment, they should learn from those assessments [8]. The observation conducted at five schools in Yogyakarta city in the last 2015 indicated that many teachers didn't assess students exhaustively and focused on cognitive skills than science process skills. Undeniable, assessing both critical thinking and science process skills need more time allocation. Therefore integrated assessment can be an alternative assessment. However, the integrated assessment is limited in number so assessing students' skills can't be exhaustively.

One of the matters in chemistry that need critical thinking and science process skills is acid and base because it connected with others matter such as chemistry reaction, equilibrium, and stoichiometry [9]. Acid and base necessary closely related to everyday life. Thus, assessing students in acid and base matter should cover critical thinking and science process skills indicators which can be measured by using integrated assessment. By realizing the importance of integrated assessment instrument, the goal of this research study was to validate an integrated assessment instrument for measuring students' critical thinking and science process skills on acid base matter. This instrument contains 11 items which each item covers two indicators at once.

## RESEARCH METHODS

Three peer reviewers from postgraduate students and eight experts which consist of four teachers and four lecturers participated. All teachers who taught chemistry in grade XI worked in different school. The integrated assessment instrument was administered to a total of 392 high school students in grade XI in the academic year of 2015/2016 at five schools in capital city of Yogyakarta. This research adapted test development model by McIntire [10] through nine steps which were (a) defining the test universe, audience, and purpose; (b) developing a test plan; (c) composing the test items; (d) writing the administration instructions; (e) conduct piloting test; (f) conduct item analysis; (g) revising the test; (h) validation the test; and (i) complete the test manual. The initial product was served by peer reviewers and validated by experts.

Integrated assessment instrument was validated in order to represent what it is supposed to measure. Validation process involved theory and evidence collection to support interpretation against test score [11]. Content validity through Likert scale was processed from validation score and analyzed by using Aiken's V [12]. Obtained V coefficient was matched to table of right-tail probabilities for selected values of the validity coefficient by Aiken [13]. If the coefficient less than 0.4 then the validity is poor, 0.4 – 0.8 is average, and more than 0.8 is good [14]. The mathematical form of the Aiken's V is [13]:

$$V = \frac{\sum s}{[n(c - 1)]}$$

Collected data were coded, initially in Excel spread-sheet, and then transferred to SPSS 16.0 data editor for data analysis. Exploratory Factor Analysis (EFA) is a powerful tool for explicating construct. Interpretation from this analysis is used to describe estimation upon dimension which can be measured from integrated assessment instrument. Thus, EFA is used as an assumption of unidimensionality. Factor analysis began with examine the adequacy of the sample, then computer arranged variance-covariance to calculate eigen value. The eigen value is used to calculate the percentage of explained variance, at once describe scree plot [15]. Factor analysis output covers Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO), Bartlett's test, scree plot, and ant- images matrices. Table 1 shows the interpretation of the KMO [16].

**Table 1.** Interpretation Guidelines for the Kaiser-Meyer-Olkin Test

KMO Value	Degree of common variance
0.90 to 1.00	Marvelous
0.80 to 0.89	Meritorious
0.70 to 0.79	Middling
0.60 to 0.69	Mediocre
0.50 to 0.59	Miserable
0.00 to 0.49	Don't factor

## RESULTS AND DISCUSSION

### Qualitative Results by Peer Reviewers and Experts

Initial product was observed by peer reviewers and the results suggested that item number 1 to 8 should be revised. All suggestions from peer reviewers to be considered, but not at all are used. Improvement was done based on its suggestion then product was validated by experts to make extent improvement. All items that have been validated by experts were arranged to receive, revise, and eliminate item. The result shows that there is no eliminated item, nevertheless only three received items. Almost all of suggestion from experts associated with sentence structure. Because the time allocation of just 90 minutes, all items should be understood by students and do not use the term elusive. In addition to considering the use of language, revision of the instrument was also done on the acid and base concept.

### Content Validity and Interpretation

Besides the qualitative data, the validation process is done based on validation sheet. Quantitative data analysis used Aiken formula to calculate content-validity coefficient based on the validation by 8 experts. Data analysis of content validity is shown in Table 2. Based on Table 2, the lowest Aiken's V index is item 2 and 5 which is 0.75, while the highest is item 9. On the other words, item 2 and 5 is stated on average category, while the rest is stated on good category. In addition, valid item is stated on good category when Aiken's V index is more than 0.8 [14]. Because Aiken's V index minimum that must be obtained at 5% significance level is 0.75, the result indicates that all items are valid in content based on table of right-tail probabilities for selected values of the validity coefficient by Aiken [13]. Overall content validity coefficient of integrated assessment instrument based on 8 experts is obtained at 0.85.

**Table 2.** Aiken's V for each Item

Item	Aiken's V
Item 1	0.83
Item 2	0.75
Item 3	0.88
Item 4	0.83
Item 5	0.75
Item 6	0.90
Item 7	0.80
Item 8	0.88
Item 9	0.96
Item 10	0.92
Item 11	0.88

### Construct Validity and Interpretation

Unidimensionality means each item only measure one dimension, which is students' ability in chemistry. Thus, each item is expected only to measure students' ability in chemistry on acid base matter. Factor analysis began with examine the adequacy of the sample, then computer arranged variance-covariance to calculate eigen value. The eigen value is used to calculate the percentage of explained variance, at once describe scree plot. The output covers Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO), Bartlett's test, scree plot, and anti-image matrices.

**Table 3.** Result of KMO and Bartlett's Test

<b>Kaiser-Meyer-Olkin Measure of Sampling Adequacy</b>		0,714
<b>Bartlett's Test of Sphericity</b>	Approx. Chi-Square	446,201
	Df	0,55
	Sig	0,000

KMO measure of sampling adequacy was 0.714, and Bartlett's test of sphericity was significant ( $\chi^2 = 446.201$ ,  $p < 0.05$ ). Both the KMO and Bartlett's test suggested that factor analysis was feasible because obtained KMO is more than 0.5 and Bartlett's test has significance less than 0.05 [16]. In addition, based on Table 1 the KMO is in category

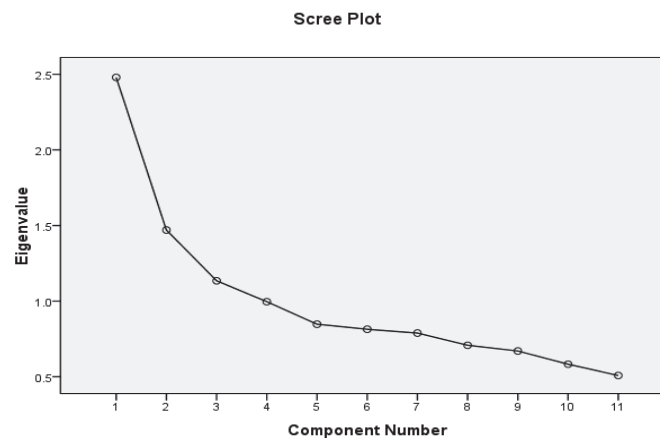
middling. In other words, the sample size of 392 students is enough. Bartlett's test provides evidence that the observed correlation matrix is statistically different from a singular matrix, conforming that linear combinations exist. In summary, the result of KMO and Bartlett's test is shown in Table 3.

The unrotated factor model suggested that there were three factors components satisfying the eigen values criterion. In factor analysis, table of total explained variance are important source of information about the number of significant factors. The result of total explained variance is shown in Table 4. The first column in Table 4 lists all variables (the 11 items of the scale) as the initial number of factors. The second column shows the eigen values (the variances of these factors). In the next two sub-columns, the variances are shown as the percent variance and the cumulative percentage variance accounted by the factors. Table 4 indicates that integrated assessment instrument contains three factors. If eigen values less than one, then that factor couldn't be described furthermore due to lack of information. Unidimensionality can be seen from the first eigen values which is more than 20% [17]. In table 4 the first eigen values is 22.539%, so the unidimensionality requirement has been fulfilled. In the other words, the integrated assessment instrument found to comply in the construct validity.

**Table 4.** Total Explained Variance

Component	Initial eigen values		
	Total	% of Variance	Cumulative (%)
1	2.479	22.539	22.359
2	1.470	13.365	35.904
3	1.134	10.313	46.217
4	0.996	9.057	55.274
5	0.847	7.702	62.976
6	0.814	7.400	70.375
7	0.789	7.171	77.547
8	0.708	6.439	83.986
9	0.670	6.095	90.081
10	0.583	5.301	95.381
11	0.508	4.619	100.000

In addition, many factors formed can also be seen through the scree plot. Figure 1 demonstrates the scree plot of the eigen values and factors from the extraction seen in Table 4. The scree plot figure that there are three bends while from component number 4 and so on indicates that sloping graphic has the same eigen values – in other words the eigen values has lower value than factors before. Practically, it is hard to find item that only measure one dimension.



**Figure 1.** EFA Scree Plot

## CONCLUSIONS AND SUGGESTIONS

According to the findings of this research, the integrated assessment instrument is valid in content and construct. The findings support the integrated assessment instrument to measure critical thinking and science process skills on acid base matter. Our interest when designing this research stemmed from our desire to assess student on both cognitive and skills aspects in chemistry. Due to the limited work in this area, our first step was to design integrated assessment instrument, so that validity of the instrument could be measured. For further study, characteristic of the instrument can be examined. Besides, the integrated assessment instrument can be designed for other matter in chemistry. By applying the integrated assessment instrument, not only assess students' cognitive but also students' skills in a certain period and effective way.

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